

SATELLITE NAVIGATION

HEARING

BEFORE THE

SUBCOMMITTEE ON AVIATION

OF THE

COMMITTEE ON COMMERCE, SCIENCE,
AND TRANSPORTATION
UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

SECOND SESSION

ON

S. Con. Res. 69

EXPRESSING THE SENSE OF THE CONGRESS THAT THE SECRETARY OF
TRANSPORTATION SHOULD MAKE AVAILABLE FOR CIVILIAN USE
CERTAIN SATELLITE-DIRECTED NAVIGATIONAL AIDS DEVELOPED BY
THE DEPARTMENT OF DEFENSE FOR THE GUIDANCE OF AIRCRAFT

MAY 23, 1984

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SATELLITE NAVIGATION

WEDNESDAY, MAY 23, 1984

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION,
SUBCOMMITTEE ON AVIATION,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:35 a.m., in room SR-253, Russell Senate Office Building, Hon. Nancy Kassebaum presiding.

Staff members assigned to this hearing: Stephen Johnson, professional staff member, Chuck Doyle, staff counsel, and Steve Palmer, minority staff counsel.

OPENING STATEMENT BY SENATOR KASSEBAUM

Senator KASSEBAUM. The hearing will come to order. I am pleased to welcome my colleague, Senator Charles Percy from Illinois before the committee today. Senator Percy's interest in the subject of air navigation systems has resulted in Senate Concurrent Resolution 69, and has provided the impetus for this hearing.

I think it is an enormously important subject on which we should get as much on the record as possible as we look to the impact of the systems on the future.

The entire world was shocked by the downing of the Korean airliner last September, and anything that could help prevent such a tragedy is worth exploring. I think that is one thing that Senator Percy felt, which gave impetus to his resolution.

Today's hearing really goes beyond that subject, however. We are here to take a look at what aircraft navigation and surveillance systems may look like in the next century. The three satellite-based systems represented here today hold great promise for the streamlined and highly accurate handling of aircraft.

I must point out, however, that these systems are some time away from large-scale implementation as air traffic control tools. They must not be allowed to divert our attention from the current national airspace systems plan which uses current technology to update our air traffic control system.

[The bill follows:]

98TH CONGRESS
1ST SESSION

S. CON. RES. 69

Expressing the sense of the Congress that the Secretary of Transportation should make available for civilian use certain satellite-directed navigational aids developed by the Department of Defense for the guidance of aircraft.

IN THE SENATE OF THE UNITED STATES

SEPTEMBER 26, 1983

Mr. PERCY submitted the following concurrent resolution; which was referred to the Committee on Commerce, Science, and Transportation

CONCURRENT RESOLUTION

Expressing the sense of the Congress that the Secretary of Transportation should make available for civilian use certain satellite-directed navigational aids developed by the Department of Defense for the guidance of aircraft.

Whereas an unarmed South Korean commercial air transport plane was shot down on September 1, 1983, with the loss of two hundred and sixty-nine lives, including many American citizens;

Whereas the Korean Air Lines jet had apparently strayed off course into Soviet-controlled airspace;

Whereas the cause for the deviation from the plane's assigned route of flight is still under investigation and may never be known;

Whereas the current aviation system is safe if internationally recognized procedures are followed;

Whereas the Government of the Soviet Union has arrogantly declared that in the future if another civilian aircraft strays off course and enters Soviet airspace it would repeat its inhuman behavior, ignoring procedures developed to protect passengers;

Whereas there is an urgent need to provide pilots with additional navigational backup systems to prevent aircraft from straying off course and to protect passengers from becoming victims of the renegade behavior of the Government of the Soviet Union or other nations with similar disregard for the lives of innocent people;

Whereas the Department of Defense has developed the Global Positioning System (hereafter in this concurrent resolution referred to as the "GPS") that can provide highly accurate navigational information to civilian aircraft as early as 1988;

Whereas the GPS could be implemented before the date to provide at least partial coverage near the borders of nations which have threatened and continue to threaten civilian airliners that may accidentally go off course; and

Whereas commercial airlines and general aviation operators have opposed the imposition of a surcharge because it would set a precedent for the charging of fees for other navigational aids, and such operators have declared that they may not use the system if a surcharge is imposed: Now, therefore, be it

- 1 *Resolved by the Senate (the House of Representatives*
- 2 *concurring), That it is the sense of the Congress that—*

1 (1) the Secretary of Transportation make available
2 the civilian version of the GPS to domestic airlines and
3 to the commercial airlines of those countries which
4 strictly abide with both the spirit and letter of the In-
5 ternational Air Services Transit Agreement, done at
6 Chicago on December 7, 1944;

7 (2) the Secretary of Transportation should work
8 with relevant agencies to speed up the timetable for
9 the civilian use of the GPS in international airspace;
10 with particular attention to the use of such system in
11 the North Pacific, including the availability of on-board
12 receivers;

13 (3) the Secretary of Transportation should encour-
14 age both domestic- and foreign-flag carriers to test the
15 GPS before its operational implementation; and

16 (4) the Secretary of Defense should not consider
17 imposing user fees for foreign and domestic civilian use
18 of the GPS in view of the benefits of such system to
19 public safety.

20 SEC. 2. The Secretary of the Senate shall transmit a
21 copy of this concurrent resolution to the Secretary of Trans-
22 portation and the Secretary of Defense.

Senator KASSEBAUM. Our first witness today will be Senator Percy. It is a pleasure to welcome you, Senator Percy.

STATEMENT OF HON. CHARLES H. PERCY, U.S. SENATOR FROM ILLINOIS

Senator PERCY. Thank you very much, Madam Chairman. It is a pleasure to be with you. I do appreciate the opportunity to testify this morning on behalf of Senate Concurrent Resolution 69 which I introduced on September 26, 1983, in response to the unjustified and brutal attack on Korean flight No. 007, an unarmed civilian airliner which strayed over airspace controlled by the Soviet Union.

Madam Chairman, so many times we are dealing with the immediately urgent, we forget the ultimately important, and once an event has passed, the action we all resolved to take after that tragic incident sort of dissipates with time and we get about our business, and other pressures come in.

Therefore, I am very grateful indeed that you have called these hearings, and it is certainly an important day that you do so, because covered in the newspapers today is the report of the death yesterday of the Soviet general who figured in the South Korean airline incident last year, who died yesterday in East Germany. He was the spokesman for the Soviets, telling—explaining from their side what actually happened.

One reason that I did introduce the resolution after the tragic incident was because of my concern that we take the steps necessary to avoid a repetition of this horrible incident, and it could occur again and again and again unless we do something about it. And we have the technical competence to do something about it.

I wish we could change the way the Soviets behave, but I have learned through the years that that is a rather difficult assignment, and we cannot count on that. I wish we could get them to at least recognize when an airliner strays over their airspace, that we should not do what they have done, to shoot it down. But in view of their reaction to this last incident, I do not think we can count on them changing their pattern of conduct, regretfully, in this kind of a situation.

Realistically, we must provide our commercial pilots with every tool necessary to avoid flying over the airspace of the Soviet Union and other nations with similar public attitude. That is why I wrote the President on September 15, 1983, urging that the fail-safe global positioning system, known as GPS be made available to civilian airliners on an expedited basis. My letter was followed with the introduction of this resolution on September 26.

I understand a receiving set could be commercially built for under \$10,000, which is a very small price for an air carrier to spend in view of the benefits involved. Madam Chairman, I would even suggest that all carriers flying into the United States, whose routes take them near hostile states, such as over the North Pacific, might be required by the FAA to be equipped with a functioning GPS system after the system has been thoroughly field-tested.

After I wrote to the President, Madam Chairman, I am pleased to say that one of the major goals of the resolution has already

been achieved. The White House has announced that it will make GPS available to civilian airliners of the world later this decade, when the system becomes fully operational.

The recently concluded investigation by the International Civil Aviation Organization bears out the urgent need for the use of the GPS. As you may know, investigators concluded that navigation errors may have contributed to the aircraft straying more than 350 miles off course. That is, we must recognize the fact that existing navigational systems are prone to human error.

It is just like, how many times do we ourselves dial the wrong number on a dial phone, or just transpose a couple of the numbers on it. Although we may never know, a simple inversion of grid coordinate numbers by the crew could have strayed the plane off course and set the stage for this tragedy.

GPS can provide crew members with an independent positioning monitor as a backup to existing systems. All a crew would have to do is flip a switch. According to Rockwell International which pioneered this system, a pilot flying anywhere on the globe could automatically identify his location to within the precision of one football field almost. If the existing navigational system and GPS showed differing positions, the pilot would be alerted to a possible error. He would also know his altitude and speed, valuable information which would help to avoid midair collisions over oceanic routes.

As I have indicated, the cost of \$10,000 estimated per set is very modest cost for an air carrier, and certainly those routes that go over the north Pacific are the most vulnerable.

One other major provision of the resolution urges that no fee be charged to commercial aviation users of the GPS system. Imposition of that fee could retard commercial acceptance of this system. I am pleased to state that the Defense Department shares these views.

I would like to conclude by urging the Federal Aviation Administration to begin making plans to field-test GPS as soon as possible. When the system becomes operational in 1988, we should be ready to remove the great risk to commercial international air transport posed by the Soviet Union and other states with little regard for world opinion.

Senator KASSEBAUM. Thank you very much, Senator Percy. I am pleased that you feel the thrust of your resolution has already been acknowledged and that the importance of such a study and efforts are underway. It is the purpose of this hearing this morning to pull together some different testimony as far as the user fee concept, the surveillance aspect just how and if it can be integrated into the NAS plan.

These are all questions that I hope will come out through the testimony this morning. It is a subject with which I am not that familiar, and I am looking forward to hearing the various testimony as we shape some opinions regarding what has to be a very crucial area, not only legislation, but certainly technological development for us in the future.

The potential is just enormous, as you pointed out. And I appreciate your initiative in really getting this off the ground as far as our paying attention to the subject.

Senator PERCY. I would just want to again thank you for holding these hearings, and also comment on the record that with your own background in both areas, international relations and in commerce and in international flight, you can well appreciate the significance of yet another 007 incident, and must remember that there were those who called for cutting off diplomatic relations with the Soviet Union; we, walking out of the START talks and arms control, canceling our 5-year grain agreement, cutting off trade and commerce with them because of the rage of the world. And there were those who were highly motivated, who simply said we ought to let them have it on this one.

It could happen again. The second one, the reaction might even be worse. This is the best thing we can do, is to prevent those kinds of things happening. And there are steps that we can take. I have faith and trust that they will see the light next time, and recognize that world wrath is not worth their not at least admitting they did it and apologizing and paying compensation. But we cannot count on that.

What we can count on is our technically solving this problem and making it far less probable in the future, because it could happen again, just as it did before.

Senator KASSEBAUM. Thank you very much, Senator Percy.

The next witness, Mr. Cittadino. It is a pleasure to welcome Mr. John Cittadino, Director of Theatre and Tactical 3, Department of Defense. Good morning.

STATEMENT OF JOHN CITTADINO, DIRECTOR OF THEATRE AND TACTICAL 3, DEPARTMENT OF DEFENSE

Mr. CITTADINO. Thank you, Madam Chairman.

I am here this morning on behalf of Secretary Weinberger to speak in support of Senator Percy's resolution. We have a briefing prepared. The outline is shown here in the vu-graph. We will give you a very short review of the status of the GPS Development Program, discuss briefly the relationship that has been going on for several years between DOD and DOT in coordination for the civil use of GPS, and give you the status of the present views on GPS user charges.

[Slide.]

The GPS system, of course, will provide the Department of Defense and military forces with unparalleled capabilities based primarily on the accuracies that you see shown there in the first bullet. For the first time, we will have the capability worldwide, in all weather, to position our forces and provide weapons systems with the accuracy that they need to deliver munitions.

In addition, the GPS will also carry sensors to detect nuclear detonations. So it is also part of our strategic deterrent, if you will.

[Slide.]

The program is being developed in three phases: the space segment, the control segment, and the user equipment. There are presently seven GPS satellite launches that have been successful. Five R&D systems are presently in being, so we do at this time have capability to exercise GPS in a limited capability. Three more

are scheduled, and I have a schedule calendar that I will show you when that will take place, coming up.

The control segment has an interim system that is in being. The principal control station on an interim basis is at Vandenberg Air Force Base. The ultimate control segment is presently in development by IBM. The user equipment—we have two contractors participating in the user equipment development. We have had some development problems which have caused some slippage in the user equipment development program. Those problems we feel now have been resolved, and we do have the program back on schedule and intend to go into production for military user equipment in January 1985.

Now, I would like to point out at this juncture that the Defense Department is only developing user equipment for the military. However, we will and have been talking to FAA and other civil users with respect to developing the standards which might be necessary for industry to develop a commercial user industry which would be compatible with the GPS system.

[Slide.]

This is a not-too-clear photo of the GPS satellite. And as shown below, a GPS constellation will consist of 18 active satellites, with three in-orbit spares. We will use an inclined orbit 12-hour period. This will allow that there will be always four to seven satellites in view of user equipment, and this would provide the necessary information to the user equipment to provide 3-D accuracy at all times.

The 7½ year-design life that you see here is based upon analysis. We have found in actuality with satellite systems of this type, that that is a very conservative estimate.

[Slide.]

This shows you the location of the ground control segment. The principal location will be in Colorado Springs. It will be a hardened site, and there will be four additional monitor stations, as shown on the vu-graph.

[Slide.]

Operational Control System



This is a family of user equipments that we are developing. The two contractors that you see are Rockville Collins and Magnavox. We will develop, or we are developing equipment to go on an entire family of military weapons systems that run the gamut from MANPAX for an infantry user, for instance, right up to tanks, high-performance aircraft like the F-15 and F-16, submarines, and carrier aircraft.

The reason for these three families of equipments are to provide the high accuracy, which naturally would become the high-cost equipment for those platforms that needed it, and then offload the capability and get the lower cost for the lower performing systems, such as the foot-soldier who is not moving so rapidly and does not need the rapid reaction time.

[Slide.]

As shown on this schedule vu-graph, we will have our initial operation with a 2-D capability at the end of 1987 when we will have 12 satellites in orbit. The ultimate capability, the 3-D capability, will be with 18 satellites in the latter part of 1988.

The control segment will be installed in 1985 and it will transition from the R&D community to the Operational Space Division somewhere in 1987. The lower part of the vu-graph shows the development of the user equipment which is presently in development, in operational test. We expect to have our production decision the beginning of next year, and move the user equipment into production.

I failed to mention that we are in production with the space segment. We are procuring 28 satellites on a production contract.

[Slide.]

Now, I am going to switch into our coordination with the Department of Transportation on this program. We initially signed a memorandum of agreement in 1979, which basically laid out the ground rules under which we would cooperate for the civil use of GPS. Together with the FAA, we produced the Federal radionavigation plan which was submitted to Congress in 1980. We updated it in 1982, and we are presently giving it its second biannual update for 1984.

The core of that plan includes GPS as a major part of the navigation system for the United States. We, in addition, have a joint position and navigation group, in which we and the FAA jointly participate. We meet periodically, approximately quarterly, to discuss issues not only on GPS, but other Federal navigation systems.

There are two technical issues that perhaps remain somewhat unresolved from the standpoint of the FAA. But the DOD position is that we have these adequately covered. The two issues are coverage and integrity of the system. The definition of the coverage of the system goes back several years ago, when the Department made the decision to go from a 24-satellite configuration to an 18-satellite configuration for reasons of economy. In doing that, we created a situation where there will be gaps in the coverage over the worldwide area, where there may be up to 30 minutes where we do not provide the full visibility to the necessary satellites to give the complete 3-D accuracy, and this would cause a gradual degradation of the accuracy from the 100 meters that we specify.

Now, these areas of noncoverage are predictable. You know when they are going to happen, and by combining GPS with other avionics aboard an aircraft, for instance, such as an inertial navigation system, you can very easily fly through these periods of outage without any appreciable degradation. And, since all of our commercial airliners have the inertial navigation systems onboard, it would be a relatively simple job technically to integrate the two. Certainly, that is how we will do it. In the military, we will integrate GPS with our other systems, so we in DOD do not see that as a major problem.

The second area of technical discussion is the problem of integrity, and the definition of that is that there is a requirement that users be notified within 10 seconds if there is any outage in the system. We have designed into the GPS equipment centers, diagnostic testing which will automatically alert users that the system is not performing in the manner in which it should.

In addition to that, we feel fairly confident that we have built an extremely reliable system. We have had seven satellites in orbit for an average of four years each, so we have 28 satellite years of performance on our R&D system, and we have only had one failure which would have created the type of problem that would cause us this 10-second warning issue.

We feel we have corrected that problem. The problem happened in a rubidium clock which was onboard the satellite. We have now included a second type of clock, and we do not anticipate ever to see that problem again. So we have great confidence that we have built an extremely reliable system.

[Slide.]

I would like now to switch to the question of GPS user charges and, of course, the very essence of Senator Percy's resolution is to remove those user charges to allow a wider acceptance of GPS for civil and commercial applications.

[Slide.]

First, I would like to give you the definitions of the two types of navigation services that we will provide. The standard positioning service [SPS] is that service which will be provided to the civil community. The precision positioning service is the very accurate service that our military forces will use, and it of course will be encrypted and it will have antijam, antispoof capabilities, so that our enemies would not be able to take advantage of that type of a signal.

[Slide.]

The idea of user charges for GPS emanated within the Department of Defense back in the 1979 timeframe when Defense did establish a policy that we would be willing to share GPS with the civil world. We have done numerous studies since then, and we accelerated those studies subsequent to 1982 when the fiscal year 1982 authorization and appropriation bills of Congress directed us to do a study and plan to implement user charges.

We have now completed this study, and I will give you a run-down of the results of that study. But as a result of the study, we have now delivered to the Appropriations and Armed Services Committee of both Houses, our report and our recommendation on user charges.

[Slide.]

We looked at four types of user charges, and I do not intend to go into the details of them, but essentially they ran the gamut from providing the same type of encryption that we are providing for military users, all the way down to just charging each time we sold a set of user equipment to whoever wanted to buy it, just add a surcharge onto the equipment that would come back into the Government Treasury.

[Slide.]

These are the criteria that we used in judging the applicability of user charges for the Department of Defense. We wanted to determine whether it would encourage users or discourage them if we had a user charge; whether or not significant revenues would come to the Government; whether it would be relatively easy to implement a user charges system; or to what degree the bureaucracy would be expanded if we had to set up an entire system to implement; whether or not the charges were enforceable; whether it was in the best interests of national security; and whether it was consistent with existing laws and policies.

[Slide.]

I will leave a copy of our study, so I do not intend to go into the chart in detail, but on the left are the criteria that I just went through, and up above are the various methods we studied. And it is pretty easy to see, if you look at that last column, that the no charge approach came out to be, in the view of the Department of Defense, the most viable way to go.

There were significant disadvantages to going to a system which we feel would be enforceable with respect to national security. If

we removed the problems of national security, we then felt we had a system that was not enforceable.

[Slide.]

So our summary on user charges, which I have got a couple of vu-graphs here, is essentially that the system, from a Department of Defense point of view, did not bring in or did not have the potential of bringing in the significant revenues to the Treasury, and it indeed would create significant problems in order to implement such a policy.

[Slide.]

So, in conclusion, as I have already stated, we felt that to implement user charges was neither practical nor desirable. And our recommendation to the Congress has included in our letters of transmittal, to delete the GPS user charges, to provide the standard service to civil users at the accuracy that we have designed into the system, and we will retain the capability to degrade the accuracy at any time national security policy dictates. We will continue to maintain control over the system.

That concludes what I have to say, except to reiterate that the Department of Defense is very much in support of Senator Percy's resolution.

Senator KASSEBAUM. Thank you, Mr. Cittadino. I would just like to ask a couple of things. I am curious. Did you say we have five stations now that are operating?

Mr. CITTADINO. Yes, ma'am.

Senator KASSEBAUM. And how many satellites does that make?

Mr. CITTADINO. We have five satellites in orbit that are presently operating, and these are being used by both the military and the civil world.

Senator KASSEBAUM. Being used by both. We have had as many as seven?

Mr. CITTADINO. Yes.

Senator KASSEBAUM. Well, how would this have related to, for instance, the KAL—

Mr. CITTADINO. Well, unfortunately, with only seven satellites, there are very narrow windows when enough satellites are visible to any particular spot on the earth, in order to get the performance that you need. There are large periods of time when you cannot see any of the satellites with user equipment.

So in the R&D phase, you certainly could not rely on the existing five satellites to give you the type of coverage that the commercial aviation world would require to adopt GPS as a civil system. It will require that we get the full 18 satellites up, as a minimum.

The Department of Defense would like, from an operational point of view, to go to a 24-satellite constellation. That, of course, would remove that problem of coverage that I talked about earlier.

Senator KASSEBAUM. How is it being used by the civilian sector now?

Mr. CITTADINO. There are limited numbers of user equipments that are out.

Phil, can you fill me on some of these?

Colonel BAKER. It is really not used by the aviation community all that much, because the coverage, like Mr. Cittadino said, only happens for a couple hours a day in a particular location. With the

five satellites we have now, there are a lot of people that use it where an accuracy is just needed, where they don't need real-time, all-the-time accuracy. For instance, in mineral exploration it is used. It is used for surveying and that type of thing.

I know the Texas Highway Department has been using it. Some of the oil companies have been using it for offshore locations at least to help their other systems.

Senator KASSEBAUM. Now, for that kind of use, there is no charge. I mean how does one make an application for that use? Do they apply to DOD?

Mr. CITTADINO. No, ma'am. It is just a matter of buying a set of user equipment, and the R&D system does not have any encryption on it. It was not meant to have. It was very similar to our transit satellites which are the existing operational navigational satellite systems that were put up several years ago. That is being used by many users.

I might add, there are a very limited number of user equipments that are available and primarily they are being used, for experimentation to see what the system would give them, although such people as the oil industry, mineral explorers, who do not have to have 24-hour-a-day performance, can afford to wait for the constellation in the R&D satellites to be in view of their area, and then get their readings based upon the short period of time that the system is available.

Senator KASSEBAUM. Well, you will have to excuse me, because I am just asking questions that probably many in this room know. But for the user equipment, is that, say, by civilian use, someone wanting to use it, purchased from DOD or from Rockwell?

Mr. CITTADINO. Well, as a matter of fact, there are, I believe, three companies.

Colonel BAKER. Texas Instruments built one. Rockwell, Magnavox, Stanford Communications, I believe.

Senator KASSEBAUM. But the purchase is from them?

Mr. CITTADINO. Yes, ma'am.

Senator KASSEBAUM. Has DOD given any thought to the security implications of any other systems that are not under DOD control? You have control essentially over the system. As you said, you could cut it off and blank it out when it is a problem. Has there been any thought given to other private systems that are in development?

Mr. CITTADINO. Yes. We have given a lot of thought to all of the systems. We do not particularly see them as a threat to national security in any way, based upon what we understand of their technical characteristics at this point.

Senator KASSEBAUM. Well, I am sure that is true. But I mean, would DOD feel there should be some control over which they could indeed make a decision that this might be—have implications for national security and blank it out?

Mr. CITTADINO. I do not think we have reached the point of making that type of a decision. I would suspect, like all radionavigation, in wartime U.S. systems revert back to the control of the Department of Defense, and the President would have the power, if there were a problem, to turn them off if that be necessary.

But we certainly have not reached the point with the development of other systems in GPS where they have reached the point where they are imminent, if you will. They have sort of been proposed, they have been talked about, but we are not sure just whether or not they are going to go ahead and prove to be economically feasible to the point where someone would come up with the venture capital to actually build one.

Senator KASSEBAUM. You said that it was found by DOD studies that the user charge was just not feasible or workable at this point. Has DOD looked at any other means of reimbursement?

Mr. CITTADINO. We have indeed looked at the four methods of reimbursement that we show in our study. We have looked at means of—we are continuing to look at means of reimbursement for the military signal with respect to our allies. And that one is still under review.

But there is another potential way of reimbursement which would require the cooperation of the Department of Transportation. There is the potential of adding to the national—I am not sure of the correct name of the tax that is put on commercial aviation.

Senator KASSEBAUM. The aviation trust fund.

Mr. CITTADINO. The aviation trust fund. But that is not our control. We have not looked at it seriously, but that is the only other way that I know of that might bring money back into the Treasury.

Senator KASSEBAUM. Thank you very much, Mr. Cittadino.

Mr. CITTADINO. Thank you.

Senator KASSEBAUM. The next witness, Mr. Albrecht.

It is a pleasure to welcome you, Mr. Albrecht, the Associate Administrator for Development and Logistics, Federal Aviation Administration.

STATEMENT OF A. P. ALBRECHT, ASSOCIATE ADMINISTRATOR FOR DEVELOPMENT AND LOGISTICS, FEDERAL AVIATION AD- MINISTRATION

Mr. ALBRECHT. Thank you, Madam Chairman. It is a pleasure to be here today to discuss Senate Concurrent Resolution 69, expressing the sense of the Congress that the Secretary of Transportation should make available for civilian use certain satellite-directed navigational aids developed by the Department of Defense for the guidance of aircraft. I would like to address this issue by giving you some background information on FAA's involvement in exploring the use of satellite systems for civil air navigation.

Over the past several years, we have intensively studied NAVSTAR GPS for various potential NAVSTAR GPS constellations and we are continuing our investigations on system coverage, reliability, and integrity in conjunction with the Department of Defense.

FAA has done extensive R&D work on NAVSTAR GPS airborne equipment. Specifically, we have completed avionics cost studies; we have conducted analyses of several satellite navigation system proposals; developed and tested a dual-channel GPS receiver functionally acceptable for national airspace system applications; we have extensively tested the DOD-procured "Z-Set" GPS receiver in the en route, terminal and nonprecision phases of navigation; and

we have conducted extensive flight simulator tests of GPS to establish its performance in several regimes of flight.

We are currently studying the possible effects of helicopter rotor modulation on navigation performance. In addition, DOT has a representative in the NAVSTAR GPS Joint Program Office, which has helped us keep abreast of system activity on a day-to-day basis.

We have worked closely with the Department of Defense in assessing the characteristics of NAVSTAR GPS as they will apply to civil aviation use. Our conclusion is that the system has the potential and the accuracy to perform virtually any air navigation task, down to and including nonprecision approach. Unlike other systems we have examined closely, NAVSTAR GPS has the potential to provide navigation in any part of the world. Further, it can provide services in mountainous terrain essentially to the surface of any airport in the world also.

The user community has not stated a clear requirement for significantly improved domestic navigation except to serve helicopter operations. Over oceans, inertial navigation systems [INS] are good and getting better, and they have been approved as a "sole means" of navigation. The INS system may be used in appropriately redundant installations, without the need for other navigation aids. However, the more accurate navigation available from satellite navigation systems may well be desired in the future as oceanic traffic builds and reduced aircraft separation standards are sought after.

Like INS and Omega, NAVSTAR GPS will have the capability to provide aircraft position data which can be automatically remoted by data link systems to ground air traffic controllers. This function, termed "automatic dependent surveillance" is an attractive system improvement for both safety and efficiency in areas where radar is not available. In addition, NAVSTAR GPS may provide a lower undetected error probability, thus potentially enhancing the utility of automatic dependent surveillance.

In the wake of the tragedy of KAL 007, the President stated that NAVSTAR GPS services would be made available to civil aviation if the potential for future tragedies could be averted thereby. No one knows whether the availability of a backup navigation system such as NAVSTAR GPS or Omega could have prevented the Korean Air Lines tragedy, but it was the President's wish to assure that the unique worldwide navigation capability of NAVSTAR GPS would be available in the interests of international aviation safety.

Initial civil use of NAVSTAR GPS is expected to be on a supplementary system basis with other inputs required to assure continuous navigation capability throughout the world's airspace. We have considered various approaches to providing the supplementary inputs. These include pressure altitude inputs from a precision altimeter system onboard the aircraft, a more precise clock which forms a part of the GPS receiver system in conjunction with other systems such as inertial and VOR/DME navigation systems. We believe that in the long term NAVSTAR GPS must be a "sole means" system if it is to realize its full civil potential. We are working with the Department of Defense to determine the best method of resolving the remaining questions on system reliability, coverage, integrity, and cost recovery.

We are looking to see how many satellites would be required in order to provide reliable U.S. and worldwide coverage. It appears that at least five satellites must be visible above a 10-degree elevation angle, with each combination of four satellites providing good position fixing accuracy. Certain technical changes may be needed in the monitoring of a system to assure rapid systemwide failure detection and warning capability—a critical requirement for civil aviation operations. If those changes are made, NAVSTAR GPS with its high accuracy perhaps could become a “sole means” air navigation system in the United States and potentially in other parts of the world.

We feel the consideration of early civil aviation use of NAVSTAR GPS for over selected oceanic areas, such as the North Pacific before 1988 is not a practical possibility. Such an implementation would add additional costs to the program, possibly compromise operational capability by disrupting an already-tight DOD plan aimed at systematically testing NAVSTAR GPS component elements and attaining the presently conceived operational use by 1988.

The alternatives we have examined would only allow a limited early use period of about one year ahead of the present schedule, and would require the provision of an expensive airborne atomic clock as well as precision altimeter inputs.

We suggest instead that the current planned schedule for GPS be maintained, and starting in 1988 NAVSTAR GPS could be used with INS or Omega as an aviation oceanic navigation system until the NAVSTAR GPS system is upgraded to where it can be approved for “sole means” use. Domestic use of NAVSTAR GPS by civil aviation would be as a supplement to existing approved systems until the requirements for “sole means” are met.

We are aware that the Department of Defense plans to use NAVSTAR GPS to phase out use of a number of other navigation services now being used by them. We will work with DOD and the civil user community to establish minimum operational performance standards, called MOPS, for NAVSTAR GPS starting in 1985 for use of GPS as a supplementary or as a primary navigation aid, depending on the specific capability and the resolution of the remaining issues. We see no reason why NAVSTAR GPS cannot be used in the civil system as soon as its coverage, performance, and failure detection capabilities are defined.

While we believe that VOR/DME, the current international standard short-distance navigation aid, will continue as a primary domestic civil navigation system for the foreseeable future, it may be that other systems currently in use or coming into use by civil aviation worldwide may no longer be needed. Systems like Loran C and Omega may no longer be needed after NAVSTAR GPS equipment cost is reduced to a level so that its purchase would not be an economic burden for existing users, and an appropriate transition period is allowed.

Let me turn now to the question of a special charge for NAVSTAR GPS services. This administration supports the principle that users pay for the services they utilize. As you know, the Congress has already provided a system of user charges through the airline ticket tax, aviation fuel taxes, waybill taxes, international

departure taxes, and so forth, to finance the capital investment for aviation facilities. In the past, as new services have been brought on, they too have been paid for by this means. Thus, a reasonable approach would be to recoup the cost of GPS operation allocable to civil users through their existing taxing methods.

An alternative approach, of course, would be to levy a "special" charge. The practicality of such an approach is questionable and until this morning I was not aware of DOD's conclusion in this matter, and I defer to John Cittadino.

U.S. aircraft operators who fly in virtually all parts of the free world would gain in another way from universally available high-quality navigation service. There are many parts of the world where only minimal electronic navigation services exist. Universal availability of services from a satellite system such as NAVSTAR GPS would benefit U.S. operators, as well as others.

In addition, optimum route and flight profiles, at closer than present separations, resulting in reduced fuel and flight time benefits in oceanic areas appear possible through the use of GPS in combination with the use of automatic dependent surveillance systems. Automatic dependent surveillance, in which air-derived navigation position information is automatically transmitted to controllers, is one of several improvement options recommended by the International Committee to Review the Application of Satellite and Other Techniques to Civil Aviation. This committee was formed as a follow-on to the AEROSAT project, which was to have provided oceanic aeronautical satellite communications services. The committee was established to examine the needs, and means available to meet the needs, for ATC system improvement, primarily in oceanic areas.

After working for more than 2 years, the committee made a series of recommendations which included support for reduction of vertical separation above flight level 290 to 1,000 feet; implementation and carriage of an airborne separation assurance device—that is, a collision avoidance system; improvements in navigational performance, probably within the capability of inertial navigation systems, but not excluding other options; automatic dependent surveillance—that is, the automatic readout of onboard navigation data and its transmission and presentation to the controller without human intervention, as a byproduct of improved high frequency radio or satellite data link communications capability; and improved quality and presentation of information to controllers on aircraft position and intent.

After the international committee's work was completed and strongly endorsed by a number of governments, including the United States, it was recommended that the International Civil Aviation Organization [ICAO] extend it to issues which deal with the longer term needs for communications, navigation, and surveillance system improvement of various areas of the world, and the technologies available to help satisfy those needs. After consideration, the Council of ICAO established a policy-level committee to deal with these issues.

We believe that the ICAO activity is important, and expect to participate fully. We also want to assure that the contribution the United States makes to this worldwide consideration truly repre-

sents the best interests of the United States and its aviation user community. For this reason, FAA proposed the formation of a Special Committee of the Radio Technical Commission for Aeronautics.

The RTCA Committee will examine the NAS plan system now being built, the need for additional capabilities, and the conditions under which we can realistically expect new technologies to find their way into the world aviation system. The National Aeronautics and Space Administration is offering its technology assessment expertise in this activity. New technologies are not free, and it is essential to compare the new approaches with ones being implemented around the world, to assure that they in fact do something which needs to be done, that they do it better, and that they do it at a cost which, all things considered, is reasonable.

In conclusion, we believe NAVSTAR GPS has the inherent potential to provide an enhanced worldwide "sole means" air navigation capability for all services except precision approach and landing, providing that matters of coverage, reliability, integrity, and user costs are favorably resolved. The future acceptance by the user community, strongly dependent on assured availability of the service and on availability of competitively priced avionics will have a large impact on determining if and when air use of such navigational aids as Loran C and Omega can be phased out.

The potential of NAVSTAR GPS to support eventual system improvements in oceanic and other areas of the world through improved navigation performance and as an input source for automatic dependent surveillance in nonradar areas with a low undetected error probability, could help make NAVSTAR GPS attractive to the international community.

That concludes my prepared statement, Madam Chairman. I would be very happy to answer questions.

Senator KASSEBAUM. Thank you, Mr. Albrecht. Do I understand that you basically feel at this point the Geostar system is just too expensive and there are still various areas which you feel have not been answered, and that is one reason that you would have some concerns about FAA regarding it as a sole system at this point.

Mr. ALBRECHT. Madam Chairman, do you mean Geostar or GPS? Senator KASSEBAUM. NAVSTAR, right.

Mr. ALBRECHT. We have some concerns which we believe will be resolved. Mr. Cittadino brought up the integrity question and the need to know when the satellite is malfunctioning. And to the extent the 10-second requirement can be met, that would take care of our concern in that area.

I do not think we are quite there yet, but we expect that that will happen. In terms of coverage and the 30-minute gap problem, we are concerned with overall system reliability. If you lose the satellite and you have to move another one into its place, that takes some time. We would be concerned if GPS were the only source of information available; as a supplemental system, I think this concern would be somewhat less.

In terms of cost, the \$10,000 number which was quoted is one that we have heard quoted from industry for a reasonably high-quality, general aviation receiver. Eventually, I am sure this number would come down, based on fairly substantial quantities, but that is a fairly expensive piece of avionics for the average gen-

eral aviation user, and as I am sure you have experienced, the general aviation community is not really anxious to buy new equipment all the time. So this could be a deterrent in its implementation.

Senator KASSEBAUM. What about the Geostar system, and how do you answer the suggestion that has been made that a substitute for the emergency locator transmitter could be made at this point?

Mr. ALBRECHT. Well, I think we would be concerned about that suggestion, Madam Chairman. The ELT system that now exists does work. It works well. It provides a service. Geostar is in the development stage, and we are working with Dr. O'Neill. We are keeping track of what he is doing. We have some concerns that I am sure you will address. One has to do with the capacity limit of the system, whether it has been properly sized for aviation use with the numbers of aircraft that we have. We are concerned whether or not he has built enough protection into his system against interference.

There is a problem when you have a large number of signals arriving at the same ground station at the same time in terms of sorting them out, and we hope that he is addressing this problem. There are some sources of errors that we need to work with him on, but basically I think our thought is that it is too early to pose a substitution of ELT. If someone wants to buy a Geostar receiver and use it as an added value thing that is there in addition to other services, we would have no problem with that. But I think we would be very unwilling to have it replace the current system.

Senator KASSEBAUM. Has FAA done any testing of this as a substitute in a limited manner?

Mr. ALBRECHT. No. No, we have not, Madam Chairman. I believe it is too early, really. The configuration of the Geostar system has changed over the past year. The changes have already been in the right direction to improve the system, but nevertheless it is changing, it is maturing. I think we would rather wait until it has matured before we got to the expense of testing.

Senator KASSEBAUM. I would assume that you would feel that there would be no reason to delay the implementation of the NAS plan to incorporate an alternative satellite system.

Mr. ALBRECHT. Absolutely not, Madam Chairman. No reason whatsoever.

Senator KASSEBAUM. Thank you very much, Mr. Albrecht.

Our next witness will be Mr. Knauss. It is a pleasure to welcome John Knauss, Chairman of the National Advisory Committee on Oceans and Atmosphere.

STATEMENT OF DR. JOHN KNAUSS, CHAIRMAN, NATIONAL ADVISORY COMMITTEE ON OCEANS AND ATMOSPHERE

Dr. KNAUSS. Thank you, Madam Chairman.

Because NACOA has never testified before your subcommittee, let me tell you something about our committee. The National Advisory Committee on Oceans and Atmosphere is charged by Public Law 95-63 to advise the President and Congress on matters of national oceanic, atmospheric and coastal zone policy. NACOA's 18 members are appointed by the President, and are drawn from aca-

demia, industry, and State and local government. Our work is sometimes initiated by congressional or Federal agency request, and often by initiatives from our own membership.

NACOA's interest in the NAVSTAR global positioning system [GPS] has been twofold: user access and user charges. Because of the unique capabilities of the GPS system—rapid, continuous, highly accurate, global, all-weather, three-dimensional positioning—it is expected to replace most other long-range civil navigation systems nationally and probably worldwide, and to become the principal navigation tool for marine users, as well as aviation and land users.

In my prepared testimony, I talk a little bit about our interest in this program which goes back to 1981.

A Department of Defense study, mandated in fiscal year 1982 by the Senate Armed Services Committee, assessed the feasibility of GPS user charges and forecast the number of users worldwide. The study estimate of 500,000 users worldwide is generally believed to be significantly low, because the calculations did not include recreational vessels or any land-based users.

According to the study, \$150 million will be required annually to cover all system costs, except military user equipment; and an annual charge of about \$370 would be required from each user of the GPS standard positioning system. If the number of users globally exceeds the study estimates, as we believe will be the case, then the annual fees required to recover the costs would be even lower.

Madam Chairman, let me read from a recent New York Times article which bears on this:

The Chrysler Corporation has developed an electronic navigation system for cars that will allow a driver to pinpoint his location to within a city block anywhere in the United States. The car's computer would store maps on an optical disk and display the right one on a small television screen in response to signals from NAVSTAR, the global navigational satellite system being built for the Air Force. Drivers will need only to glance at the screens occasionally to see where they are. The satellite navigational system is just one example of the electronic revolution that is expected to sweep Detroit. Chrysler engineers insist the navigational system is not just a show-car gimmick; they say they are waiting for enough NAVSTAR satellites to be launched to cover the United States, a step that probably will come in 1988. Chrysler then plans to offer the navigational system as an option targeted at a price of \$500 or less.

NACOA believes that user charges of this magnitude, or \$370 a year, compared to the purchase cost of GPS receivers, and compared to the capabilities offered, are very fair and reasonable.

Every fishing vessel that works out of sight of coastal land will have a GPS receiver. All of the offshore oil industry will use GPS. Yachts working offshore will use it. The GPS system will be used on land to measure earthquakes and movement of the Earth; one receiver will only give you about 100 meters accuracy, but in conjunction with one another, they are much more accurate, and one can see minute movements of the Earth's crust. Colonel Baker just pointed out the Texas Highway System is also using the experimental system at present. Frankly, the opportunities of the GPS system are mind-boggling.

Although I am hesitant to say so in this group, the aviation use of this system will be trivial in terms of the numbers of users—not in terms of importance—but in terms of the number of users.

One of our members who is the CEO of one of the big offshore oil service groups, who would have been here today but he is in Indonesia, asked me to give you this message: He said "tell them that all my 300 boats will have this system as soon as it is available, and all of my competition will have it as soon as it is available."

We believe cost recovery should be an integral part of the GPS system. We firmly believe that user charges should be involved. We can envision circumstances where some class of users might not be charged. We believe the President should have the flexibility to make such policy decisions. He can make GPS available free of charge to the aviation industry if he so wishes, at least the commercial aviation industry.

It appears to NACOA that the simplest and most effective way to collect user charges is probably to code or to scramble the transmitted signal, as is done on cable TV now. You can sell a device annually that will decode the signal at the receiver. The DOD study on this estimated a one-time cost of somewhere between \$20 and \$40 million to include user charge capability in the system design at this time.

This is minimal compared to the \$150 million potential cost recovery each year for 30 years from user fees. If not designed into the system now, however, future addition of user charge capability will require costly redesign and reengineering, significantly greater than the DOD estimates for doing the job at this stage of GPS development.

In summary, then, Madam Chairman, NACOA believes it is in the national interest to require the GPS users to be charged for access to this system whose development was paid for by U.S. taxpayers. We believe that the DOD estimated charges are reasonable and fair, and we strongly recommend that the option for charging fees be engineered into the system at this time.

Thank you.

Senator KASSEBAUM. Thank you very much. I could not help but think, when you were talking about the automobile study, of the recent stories that have been in the Post about the hackers that are interfering with and breaking into the system. I would hate to have a computer doing my car work and have someone start to interfere with where one is going and how.

I think the potential of all of this is really something that even applying to this—

Dr. KNAUSS. It will tell you what part of the city you are in. It will not tell you whether you are on the left or the right side of the highway.

Senator KASSEBAUM. Regarding the user fees and your strong support for that, how do you respond to Mr. Cittadino's testimony this morning and the Department of Defense has found that evidently from the various categories that they analyzed, that it would be too difficult to really impose a user fee and follow through with the collection of it?

Mr. KNAUSS. I believe that the DOD study looked at a series of possibilities, and I concur—NACOA concurs—with him that cer-

tainly all but one of those does not make any sense at all. That one is the suggestion that we have cited and the suggestion that DOD made themselves some time ago—was to use the so-called scrambling device, again analogous to what you have on your cable TV.

I think there is some problem with this in respect to some elements of national security. That is, if you make it too simple, the hackers will get in and sell you a counterfeit copy cheaply. And if you make it too sophisticated, then maybe you have difficulties with our own national security system, where we do not like to export our most complicated cryptology know-how.

But I cannot believe that some compromise can't be found between those two extremes.

I guess I am not very comfortable with his testimony on that matter.

Senator KASSEBAUM. Thank you very much. I appreciate your testimony on behalf of the members of NACOA. I guess your mentioning the gentleman with the work in the offshore, now in such a situation, it would be your thought that a user fee should be charged to everybody, each of those boats, for instance, that are equipped with it?

Dr. KNAUSS. Yes, ma'am. It would be very simple. Buy yourself a card, just slip it into your set once a year. Get a new card each year. Maybe if Mr. Iacocca really does it with Chrysler Motors, the numbers will be astronomical. We would maybe pay \$100 a year for the user fee. The money will come back to the General Treasury.

The system will be available not only for people in the United States, but worldwide. As I say, the foreign users and the civilian users are going to be much greater than will be the military users, and also much greater than the commercial airline industry on a worldwide basis.

That is my message.

Senator KASSEBAUM. Thank you very much.

[The statement follows:]

STATEMENT OF DR. JOHN A. KNAUSS, CHAIRMAN, NATIONAL ADVISORY COMMITTEE ON OCEANS AND ATMOSPHERE

Madam Chairman and members of the subcommittee, good morning. Because NACOA has never testified before your subcommittee, let me tell you something about our committee. The National Advisory Committee on Oceans and Atmosphere is charged by Public Law 95-63 to advise the President and Congress on matters of national oceanic, atmospheric, and coastal zone policy. NACOA's 18 members are appointed by the President, and are drawn from academia, industry, and State and local government. Our work is sometimes initiated by congressional or Federal agency request, and often by initiatives from our own membership.

NACOA's interest in the NAVSTAR Global Positioning System [GPS] has been twofold: user access and user charges. Because of the unique capabilities of the GPS system—rapid, continuous, highly accurate, global, all-weather, three dimensional positioning—it is expected to replace most other long-range civil navigation systems nationally, and probably worldwide, to become the principal navigation tool for marine users, as well as aviation and land users. In 1981, NACOA wrote to the Secretary of Transportation expressing concern that the views and interests of potential private users of GPS were not receiving adequate attention. We believe communications between the civil marine user community and the GPS project office have since improved.

In 1983, NACOA reviewed the GPS user charges issue. Over the anticipated 30-year life of the system, estimated costs for research and development, equipment and system operations are \$5.7 billion. As with the present global satellite naviga-

tion system, known as TRANSIT, it is expected that civilian users will far outnumber military, and that foreign users will far outnumber domestic. Thus, unless some form of user charges are imposed, the U.S. taxpayer will subsidize another navigation system to be used worldwide. Navigation systems have traditionally been provided free of charge, partly because of their humanitarian and safety aspects. But in these times of high U.S. budget deficits, many government programs designed to serve relatively small segments of the population are being reexamined with an eye to user charges.

A Defense Department study, mandated in fiscal year 1982 by the Senate Armed Services Committee, assessed the feasibility of GPS users charges and forecast the number of users worldwide. The study estimate of 500,000 users worldwide (with an average user base of 250,000) is generally believed to be significantly low, because the calculations did not include recreational vessels or any land-based users. The study assumed that \$150 million will be required annually to cover all system costs (except military users equipment) and that an annual charge of \$370 would be required from each user of the GPS Standard Positioning System. If the number of users globally exceeds the study estimates, as we believe will be the case, then the annual fees required to recover costs would be even lower. NACOA believes that user charges of this magnitude, compared to purchase costs of the GPS receivers, and compared to capabilities offered by the system, are fair and reasonable. And incidentally, several of our own Members who will be GPS users support charges for the system.

Although we believe cost recovery should be an integral part of the GPS system design, we can envision circumstances where some class of use of users might not be charged, and we believe the President should have the flexibility to make such policy decisions. The time is critical now, however, for designing and engineering GPS (especially the military receivers) to include the user charge option for civil use. Based upon our review, it appears to NACOA that the simplest and most effective way to collect user charges is probably to code or "scramble" the transmitted signal, as is done in cable TV, and sell a device annually that will decode the signal at the receiver. Any future consideration of adding such a user charge capability would then require costly and time-consuming redesign, engineering, and production efforts. The DOD-estimated one-time cost of \$20 to \$40 million to include user charge capability in the system design at this time is minimal compared to the \$150 million potential annual cost recovery from user fees.

In summary, NACOA believes it is in the national interest to require that GPS users be charged for access to this system whose development was paid for by U.S. taxpayers. We believe that the DOD-estimated charges are reasonable and fair. We strongly recommend that the option for charging fees be engineered into the system at this time.

Madam Chairman, that concludes my formal statement, and I will be happy to answer any questions from you and the members of the subcommittee.

Senator KASSEBAUM. The next witnesses—there are three who are part of a panel—Mr. Degroot, Mr. Rothblatt, and Mr. Anderson.

It is a pleasure to welcome you. Mr. Degroot is director of Avionics Systems, Collins Government Avionics Division, Rockwell International; Mr. Anderson, vice president, Mobilsat; and Mr. Rothblatt, vice president of Business and Regulatory Affairs.

Mr. Degroot, we will start with you.

STATEMENTS OF LOREN E. DEGROOT, DIRECTOR, AVIONICS SYSTEMS, COLLINS GOVERNMENT AVIONICS DIVISION, ROCKWELL INTERNATIONAL; ROY ANDERSON, VICE PRESIDENT, MOBILSAT; AND MARTIN ROTHBLATT, VICE PRESIDENT, BUSINESS AND REGULATORY AFFAIRS, GEOSTAR CORP.

Mr. DEGROOT. Thank you, Madam Chairman, for the opportunity to share some thoughts with you on what I consider to be a significant national resource, the NAVSTAR system we have heard so much about.

Yesterday I had the privilege of addressing an international symposium in London, sponsored by the Royal Institute of Navigation on the subject of navigational satellites for civilian applications. I want to assure you that there is certainly worldwide interest in the results of this hearing and on the outcome of Senate Concurrent Resolution 69.

By now, most of the world community that is concerned with safe and efficient navigation, whether for aircraft, ships, land vehicles or spacecraft, is familiar with and excited about this new space-based development. Suffice it to say, therefore, that when NAVSTAR is fully operational in 1988, the 18 NAVSTAR satellites will provide worldwide, all-weather, day and night navigation data that will permit us to fix our position within 16 meters and our velocity within one-tenth of a meter per second.

The first transatlantic flight using satellite navigation occurred last June when a Rockwell International aircraft flew from Cedar Rapids, IA, to Paris, France. During this 1983 flight, satellite availability was limited to several hours per day over a specified flight path. Yet, even with this limitation, the aircraft was able to navigate the entire distance using GPS signals exclusively, and then park at a predesignated spot at LeBourget International Airport with an accuracy of 25 feet.

According to the current, funded satellite deployment plan, in approximately 4 short years GPS will be fully operational. Prior to that time, an ever increasing signal coverage will open new opportunities for civil aviation as well as commercial users to receive the benefits of this most accurate and available of navigation systems.

I believe that the most challenging navigation issue facing the civil aviation community today relates to establishing a bold plan for introducing NAVSTAR into operational usage. Introduction of NAVSTAR into civil aviation operations can be accomplished by one of two methods: Wait until the system has been perfected to the point that it can be certified as the sole means of navigation, or establish an evolutionary plan whereby the incremental capabilities of the system can be realized as they become available.

While the first method is the more conservative, and therefore, the preference of the regulatory agencies, it suffers from the extended time required to take advantage of the capabilities that are now available. I would encourage the Congress, therefore, to consider the advantages of an evolutionary plan that would permit GPS to be introduced to the civil aviation community on a gradual, confidence-building schedule.

I believe that we can begin to experience some of the potential life savings benefits of GPS well before the total system is declared to be fully operational. Before GPS can be certified as the sole means of navigation, it can be employed to dramatically improve the safety of airborne navigation through its use as an independent position monitor. Coupled with automatic, reliable long-range communications with air traffic control centers, a GPS based independent position monitor could provide a much needed long-range surveillance capability.

It has been suggested that possible causes of the Korean Air Lines flight 007 straying off course on that fateful day included the possibility of the flight crew entering incorrect data, the possibility

of faulty crosschecking of navigational data, and the lack of radar coverage during certain portions of the flight.

Today, flight crews are totally dependent on human activity for data insertion and crosschecking of onboard navigation systems during long overwater flights or flights in remote areas where groundbased navigation aids and radar are not present.

GPS is the only airborne navigation system that is available which can establish an unambiguous aircraft position independent of initialization and without human intervention. Unlike many existing navigation systems such as inertial, GPS does not have to be initialized before it produces information. It simply must have the power switch turned on.

Our studies show that a GPS based independent position monitor could be commercially available for approximately \$10,000 in 1988 when the NAVSTAR system is scheduled to provide worldwide coverage. It seems a small cost to pay for a system that would eliminate the possibility of human input errors and improve or possibly automate the crosschecking of navigation data onboard United States and world air carrier aircraft.

A GPS based independent position monitor used in conjunction with automatic, reliable long-range communications, would be an effective way to employ today's technology to improve air safety and eliminate the absolute dependence that cockpit crews have on navigation systems which are subject to human error.

While NAVSTAR GPS could be used today to provide a sorely needed independent position monitor capability, it is necessary that perceived limitations which preclude its adoption as the sole means of navigation be resolved without delay. Limitations which have been identified by various organizations include questions relative to coverage, availability, integrity, accuracy, and cost. And, we have had some discussions so far this morning on some of these topics.

Solutions to each of these limitations, however, have been identified, and an accelerated demonstration program should be implemented to prove their adequacy to meet operational requirements. Permit me to briefly discuss each of these perceived limitations.

First is the question of coverage. When the NAVSTAR system was being considered for military applications, as Mr. Cittadino has told us, budget limitations force reduction of the operational satellite constellation from 24 to 18 satellites. That reduced constellation has created moving geographic areas where the number of satellites available to provide a reliable position fix is inadequate for the needs of the civil aviation community.

It is our view that the originally planned 24-satellite constellation would remove this limitation that presently exists in the funded 18-satellite version.

The question of availability relates to the fact that the NAVSTAR system was designed for military use and is to be operated by the Department of Defense. Some organizations are concerned that the system could be shut down by the DOD in times of national emergency or worldwide conflict. Most navigation systems in use today have had their genesis in the same manner that GPS has. Even our present-day DME system is a derivative of the TACAN system that was originally developed to meet military needs. Loran

and Omega are two additional examples that have their origins in the same way.

With President Reagan's recent offering of GPS to the world's airlines, it would appear that the concern of availability should diminish. Once an electronic navigation system has been publicly committed to civilian users, I cannot think of a single incident during which that system has been denied to civil aviation operators.

The issue of integrity is a highly technical one that involves the process of ascertaining that the NAVSTAR system is operating as expected. Several technical solutions that address this issue are a fundamental part of the NAVSTAR system. These solutions, which include both satellite and user monitoring schemes, simply require additional testing to ensure that they meet the certification requirements of the regulatory agencies.

The question of system accuracy can perhaps be better stated as the ability to have confidence in the position determination of this system. NAVSTAR, in its relatively short life, has had more extensive testing and has accumulated more data on its accuracy performance than any other navigation system has had during its developmental cycle.

Additionally, our transatlantic flight last year demonstrated the worldwide accuracy of GPS during our 4-day flight to Paris. Consistently, we were within less than 50 meters of our actual position. Capt. Charles Hall, pilot of that first transatlantic flight, summed up his confidence in the NAVSTAR system when he said, "Knowing that the system is that accurate makes you feel real comfortable up there—to be able to say with assurance, yes, we are right here where we say we are."

Finally there is the question of cost. I do not believe that this question relates to the cost of the user equipment. As I have said before, recurring cost of the civil aviation set is very attractive, a maximum of \$10,000 in 1988. Rather, the question of NAVSTAR GPS cost relates to the issue of user charges.

The potential for a special user tax has served as a severe deterrent to acceptance of NAVSTAR GPS in the civilian marketplace. Difficult questions as to how the user fee would be administered go unanswered, and that creates a great deal of confusion. There are no plans to appropriate the funding necessary to establish the administrative organization required to implement the proposed policy.

Furthermore, it is debatable as to whether the user fee would ever result in recoupment of GPS development, acquisition, and operating cost. Rather, it is probable that the administrative cost, technical support, and equipment modification costs would exceed the income provided by an affordable user fee.

As you can see, the problems involved in assessing a user tax for civilian use of GPS are significant. Coupled with the fact that there is no precedent for such a user tax policy, I would urge you to reconsider earlier congressional guidance on this matter and to direct the Department of Defense to rescind its current policy regarding the imposition of a user fee. Furthermore, I would urge that the Department of Defense be directed to not impose a user fee at any future time.

In conclusion, I would like to voice my support for Senate Concurrent Resolution 69 that has been introduced by Senator Percy. I would recommend that the Congress speed up the timetable of NAVSTAR to permit its early use by the civil aviation community as an independent position monitor. I would also encourage you to direct the FAA to expedite its development in testing of technical solutions to the currently perceived limitations so that NAVSTAR GPS can be certified as the sole means of navigation by the end of this decade.

Finally, I would urge you to eliminate from consideration the imposition of user fees for the domestic and foreign use of GPS in view of the benefits of the system to public safety. I believe that the NAVSTAR GPS navigation system is a national resource that cannot be hampered by the imposition of a user fee. The benefits that GPS can provide to the Nation and to the world dictate that the system be available in the near term to all who would use it.

Thank you.

Senator KASSEBAUM. Thank you very much, Mr. Degroot.

STATEMENT OF LOREN E. DEGROOT, DIRECTOR, AVIONIC SYSTEMS, COLLINS
GOVERNMENT AVIONICS DIVISION, ROCKWELL INTERNATIONAL

Thank you for the opportunity to share some thoughts on what I consider to be a significant national resource—the NAVSTAR Global Positioning System.

By now, most of the world community that is concerned with safe and efficient navigation—whether for aircraft, ships, land vehicles or spacecraft—is familiar with and excited about this new space-based development. Suffice it to say, therefore, that when NAVSTAR is fully operational in 1988, the 18 NAVSTAR satellites will provide worldwide, all-weather, day/night navigational data that will permit the establishment of a vehicle's position within 16 meters and its velocity within $\frac{1}{10}$ of a meter per second.

The first transatlantic flight using satellite navigation occurred last June when a Rockwell International corporate aircraft flew from Cedar Rapids, Iowa, to Paris, France. During this 1983 flight, satellite availability was limited to several hours per day over the specified flight path. Yet even with this limitation, the aircraft was able to navigate the entire distance using GPS signals exclusively and then park at a predesignated spot on the apron at LeBourget International Airport with an accuracy of 25 feet.

Rockwell International has been awarded the production contract for the NAVSTAR satellites and one of the full scale development contracts for NAVSTAR User Equipment. According to the current, funded satellite deployment plan, in approximately four short years GPS will be fully operational and worldwide navigation will be possible for 24 hours per day. Prior to that time, an ever increasing signal coverage will open new opportunities for civil aviation as well as many other commercial users to receive the benefits of this most accurate and available of navigation systems.

I believe that the most challenging navigation issue facing the civil aviation community today relates to establishing a bold plan for introducing NAVSTAR into operational usage. Introduction of NAVSTAR into civil aviation operations can be accomplished by one of two methods: Wait until the system has been perfected to the point that it can be certified as the "sole means" of navigation; or, establish an evolutionary plan whereby the incremental capabilities of the system can be realized as they become available.

While the first method is the more conservative, and therefore, the preference of regulatory agencies, it suffers from the extended time required to take advantage of the capabilities that are now available from the system. I would encourage the Congress to consider the advantages of an evolutionary plan that would permit GPS to be introduced to the civil aviation community on a gradual, conference building schedule.

I believe we can begin to experience some of the potential life saving benefits of GPS well before the total system is declared to be "fully operational". Long before GPS can be certified as the "sole means" of navigation, it can be employed to dramatically improve the safety of airborne navigation through its use as an Independent

ent Position Monitor. Coupled with automatic, reliable long-range communications with Air Traffic Control centers, a GPS based Independent Position Monitor could provide a much needed long-range surveillance capability.

In previous testimony before the Subcommittee on Transportation, Aviation and Materials of the House Committee on Science and Technology, it was suggested that possible causes of Korean Airlines Flight 007 straying off course on the fateful day included the possibility of the flight crew entering incorrect data, the possibility of faulty cross-checking of navigational data and the lack of radar coverage during certain portions of the flight.

The need for an Independent Position Monitor was also evident during the near-miss by two jumbo jets near Miami, Florida, in the fall of 1983. An Independent Position Monitor could have been used to provide an independent cross-check of both altitude and position to avoid this type of situation. Today's on-board navigation systems would not be useful in comparing altitude information since these equipments provide only latitude and longitude position data.

Today, flight crews are totally dependent on human activity for data insertion and cross-checking of onboard navigation systems during long over-water flights or flights in remote areas where ground-based navigation aids and radar are not present. GPS is the only airborne navigation system that is available which can establish an unambiguous aircraft position independent of initialization and without human intervention. Unlike many existing navigation systems such as inertial, GPS does not have to be "initialized" before it produces information. It simply must have the power switch turned on.

An Independent Position Monitor for international and domestic air carriers could use readily available GPS signals to provide accurate cross-check data for latitude, longitude and altitude within 100 meters. This accuracy could be provided without any action by the operator other than turning on the power. Compare the GPS three-dimensional accuracy of 100 meters with a maximum two-dimensional inertial navigation system error of 2 nautical miles-per-hour and Omega system errors in the range of several nautical miles.

Our studies show that a GPS based Independent Position Monitor could be commercially available for approximately \$10,000 in 1988 when the NAVSTAR system is scheduled to provide worldwide coverage. It seems a small cost to pay for a system that would eliminate the possibility of human input errors and improve or possibly automate the cross-checking of navigation data on board United States and world air carrier aircraft.

Pilots currently cross-check position data manually. The use of a GPS based Independent Position Monitor would materially enhance flight safety in long over-water routes and in remote areas by augmenting flight following services where ground-based navigation aids and radar are unavailable. With increasing air travel to remote destinations, the importance of accurate navigation continues to increase. Tolerances of 5 to 10 miles may be acceptable today, but could lead to future over-flights of unfriendly territory. As noted in earlier House testimony, North Pacific Route R-20, which was the intended route of Korean Airlines Flight 007, is only 52 nautical miles from Soviet airspace at one point. There are numerous other routes around the world where air carriers operate much closer to unfriendly borders.

A GPS Independent Position Monitor, used in conjunction with automatic, reliable long-range communications, would be an effective way to employ today's technology to improve air safety and eliminate the absolute dependence that cockpit crews have on navigation systems which are subject to human error.

While NAVSTAR GPS could be used today to provide a sorely needed Independent Position Monitor capability, it is necessary that perceived limitations which preclude its adoption as a "sole means" of navigation be resolved without delay. Limitations which have been identified by various organizations include questions relative to coverage, availability, integrity, accuracy and cost. Solutions to each of these limitations have been identified, and an accelerated demonstration program should be implemented to prove their adequacy to meet operational needs. Permit me to briefly discuss each of these perceived limitations.

First, is the question of coverage. When the NAVSTAR system was being considered for military applications only, budget limitations forced reduction of the operational satellite constellation from 24 to 18 satellites. The reduced constellation has created moving geographic areas where the number of satellites available to provide a reliable position fix is inadequate for the needs of the civil aviation community. It is our view that the originally planned 24-satellites would remove this limitation in the presently planned and funded constellation.

The question of availability relates to the fact that the NAVSTAR system was designed for military use and is to be operated by the Department of Defense. Some

organizations are concerned that the system could be shut down by the DoD in times of national emergency or worldwide conflict. Most navigation systems in use today have had their genesis in the same manner that GPS has. Even our present-day DME system is a derivative of the TACAN system that was developed to meet military needs. Loran and Omega are two additional examples that also come to mind. With the President's recent offering of GPS to the world's airlines, it would appear that the concern of availability should diminish. Once an electronic navigation system has been publicly committed to civilian users, I cannot think of a single incident during which that system has been denied to civil aviation operators.

The issue of integrity is a highly technical one that involves the process of ascertaining that the NAVSTAR system is operating as expected. Several technical solutions that address this issue are a fundamental part of the NAVSTAR system. These solutions, which include both satellite and user equipment monitoring schemes, require addition testing to ensure that they meet the certification requirements of the regulatory agencies.

The question of system accuracy can perhaps be better stated as the ability to have confidence in the position determination of the system. NAVSTAR, in its relatively short life, has had more extensive testing and has accumulated more data on its accuracy performance than any other navigation system has had during its developmental cycle. Additionally, our transatlantic flight demonstrated the worldwide accuracy of GPS during our four day flight to Paris. Consistently, we were within less than 50 meters of our actual position. Captain Charles Hall, pilot of that first transatlantic flight, summed up his confidence in the NAVSTAR system when he said, "knowing that the system is that accurate makes you feel real comfortable up there—to be able to say with assurance, yes, we are right where we say we are."

Finally, there is the question of cost. I do not believe that this question relates to the cost of the user equipment. We know that although the system employs new technology signal processing schemes, the recurring cost for a civil aviation set is very attractive—approximately \$10,000. Rather, the question of NAVSTAR GPS cost relates to the issue of user charges.

The potential for a "special user tax" is serving as a severe deterrent to acceptance of NAVSTAR GPS in the civilian marketplace. Difficult questions as to how the user fee would be administered go unanswered, creating a great deal of confusion. There are no plans to appropriate the funding necessary to establish the administrative organization required to implement the proposed policy. Furthermore, it is debatable as to whether the user fee would ever result in recoupment of GPS development, acquisition and operating costs. Rather, it is probable that the administrative costs, technical support and equipment modification costs would exceed the income provided by an affordable user fee.

Questions relative to product safety and product liability are almost impossible to anticipate if a user charge with its consequential operational impacts is imposed upon civil aviation operators. The concept of a police officer stopping an automobile and having a car towed away for failure to purchase an automobile license (a "special user tax") is easy to visualize. This simplistic analogy, however, does not apply when one considers civil aviation operations. Who is liable in the event of an air tragedy that is related to the Government's denial of GPS to an operator who has inadvertently failed to pay his special user tax?

As you can see, the problems involved in assessing a user tax for the civilian use of GPS are significant. Coupled with the fact that there is no precedent for such a user tax policy, I would urge you to reconsider earlier Congressional guidance on this matter and direct the Department of Defense to rescind its current policy regarding the imposition of a GPS user fee. Furthermore, I would urge that the Department of Defense be directed to not impose a user fee at some future time.

In conclusion, I would like to voice my support for Senate Concurrent Resolution 69 relating to the use of satellite navigation aids. I would recommend that the Congress speed up the timetable of NAVSTAR to permit its early use by the civil aviation community as an Independent Position Monitor. I would also encourage you to direct the FAA to expedite its development and testing of technical solutions to the currently perceived limitations so that NAVSTAR GPS can be certified as a "sole means" of navigation before the end of this decade.

And finally, I would urge you to eliminate from consideration the imposition of user fees for the domestic and foreign use of GPS in view of the benefits of this system to public safety. I believe that the NAVSTAR GPS navigation system is a national resource that cannot be hampered by the imposition of a user fee. The benefits that GPS can provide to the nation and to the world dictate that this system be available in the near term to all who would use it.

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Senator KASSEBAUM. Mr. Anderson, I will ask questions after all three of you.

Mr. ANDERSON. Thank you, Madam Chairman. It is a pleasure to present the views of the Mobile Satellite Corp. on the use of satellites for position fixing.

Mobile Satellite Corp. has applied for authority to build and operate a land and aeronautical, commercial mobile satellite system for the United States, including Alaska, Hawaii, and Puerto Rico.

The services provided by the system will include two-way voice communications for nationwide mobile telephone and dispatching services, a wide variety of digital communication services, and position surveillance.

I make a distinction between navigation and surveillance. Navigation is the process of determining onboard a craft its own position by means that did not reveal its position to others. In surveillance, a central location transmits signals out to the craft, they respond, and from their responses, the central location determines and knows the positions of all the aircraft in the controlled area.

These two functions are different and are both important, and they can both well be served by satellites. Navigation is best served by a system like the global positioning system because of its worldwide, low-altitude satellites in inclined orbits that give it worldwide coverage and high accuracy in all areas of the world, including the polar and equatorial regions.

Surveillance, however, is needed for things like air traffic control, and it is best done by geostationary satellites, because geostationary satellites are best for communications. In nearly every application of surveillance, communication is a very necessary adjunct. In air traffic control, digital communications may have some applications, but voice communications are essential.

Mobile Satellite Corp. has made a proposal to the FAA suggesting that its commercial satellites be used for the development and operation of an air traffic control surveillance system. The system that we have described to the administration is capable, using only a portion of our satellite capacity, of locating 20,000 aircraft and identifying them every 4 seconds, to an accuracy in the range of 600 to 1,000 feet, which is more than adequate for en route traffic control and collision avoidance.

One of the nice features of our system is that it uses a narrow band ranging technique, and as a result the amount of bandwidth and the cost to the FAA in using this system is proportional to the number of the aircraft that are to be served. Actually, I mentioned 20,000 aircraft. There are never that many airborne at any one time now in the United States, and most of them do not have to be located by satellites because they are over the land areas where there is very good radar surveillance.

The satellite surveillance system is useful for low flying aircraft which are below the beams of the radars in remote areas, or for aircraft that are flying over the oceans, beyond the range of shore-based radar.

Our system, Mobile Satellite Corp's. system, is only going to be designed for the United States. But it is extendable to an international service. It could be an international worldwide system.

The nice thing about our narrow and adjustable bandwidth is that the cost can be very low. If we were to supply service to the FAA to track all of those 20,000 aircraft, all the aircraft that are airborne in the United States, the cost to the FAA would be about one-tenth the cost of an FAA owned, dedicated satellite system; and for the aircraft that they actually want to use it for, it would be almost a trivial cost.

Incidentally, the equipment cost in the aircraft may be in the hundreds of dollars range. It can be a circuit added to the communications equipment as used through the satellite. The system therefore overcomes one of the big barriers in developing a surveillance system like this. It overcomes the budget barrier.

The system has been extensively tested and proven. We used NASA's application technology satellites over a period of many years to develop and demonstrate the system. And the FAA was a major participant in the early 1970's in flight testing this system. So the FAA knows that the system will work.

Mobile Satellite Corp., its principal owners are six large American corporations. We stand ready, technically and financially, to provide this land and aeronautical mobile satellite system for the United States when we can get the authorization from the Federal Communications Commission to do so. If that authorization comes through early next year, let's say, we can have the system operational in about 1988.

Thank you.

Senator KASSEBAUM. Thank you very much.

[The statement follows:]

STATEMENT OF ROY E. ANDERSON, VICE PRESIDENT, MOBILE SATELLITE CORP.

SATELLITE NAVIGATION AND SURVEILLANCE SYSTEMS

Mobile Satellite Corporation is pleased to have this opportunity to comment on the use of satellites for air traffic surveillance, communications, and navigation.

I am Roy E. Anderson, Vice President of Mobile Satellite Corporation, located at King of Prussia, Pennsylvania. The principal owners of the Corporation are: General Electric Venture Capital Corporation, Metromedia, Inc., BEA Associates, Whitcom Investment Company, Gearhart Industries and Associated Communications Corporation. In March 1983, the Corporation filed an application with the Federal Communications Commission requesting authority to construct and operate a land and aeronautical mobile satellite system to serve the United States. The land mobile services include:

- Mobile radio telephone for non-urban areas;
- Dispatch communications without range limit;
- Interactive data exchange;
- Position location; and
- Wideband data transmission with portable equipment from remote sites.

In addition, as discussed more fully below, Mobile Satellite Corporation has proposed to the Federal Aviation Administration that part of this mobile satellite system be used to provide supplementary satellite air traffic control ("ATC") surveillance, voice and data.

Navigation surveillance

In discussing this matter, distinction is made between surveillance and navigation systems. A surveillance system, on the one hand, interrogates distant craft and computes their positions at a central location. Surveillance is needed in air traffic control so that the controller can direct the craft. Navigation, on the other hand, is the on-board determination of a craft's own position by means that do not reveal its position to others. Accurate, world-wide navigation is of extreme importance to the military services. Navigation needs are best met by systems such as the Global Posi-

tioning System ("GPS") which provides highly accurate position fixes in latitude, longitude and altitude.

Surveillance and navigation are two different functions. Both are necessary, but each should be implemented with a system that is optimally designed for its purpose. We believe that the system we have proposed is well-suited for meeting recognized needs for surveillance service.

Need for satellite surveillance

Although the American aviation community is generally well-served by the existing radar surveillance system when operating over land, a supplementary satellite ATC system may be useful for low-flying rotor craft and for aircraft flying offshore.

Land-based radar surveillance is impossible over the large ocean areas because of the earth's curvature. Satellites offer the only prospect for independent surveillance. They also can provide highly reliable communications with aircraft and between control centers.

For example, the New York Air Route Traffic Control Center of the FAA is responsible for air traffic control on the Caribbean oceanic routes. At the present time, it is necessary to route aircraft with 90 mile separations along the same track, because there is no independent surveillance to confirm the actual location of aircraft in flight. Aviation industry sources indicate that, as a consequence of the large spacing, about 50% of the aircraft are assigned longer routes at unfavorable altitudes—resulting in millions of dollars of excess fuel costs a year and an average of 100 extra miles per flight with attendant higher operating costs. Closer spacing is under study, and if adopted will result in substantial savings. Independent surveillance such as that provided by satellite ATC could reduce spacing to about 10 miles.

Voice communications are another troublesome problem for the aviation community. In 1983, there were more than 200 hours of outages during periods of high traffic on the Caribbean routes. In January 1984 alone, there were approximately 35 hours of outages during which controllers could not communicate with flight crews.

The role of satellites in the National Airspace System modernization plan is not well defined at this time and, to the best of our understanding, is "under study." The Radio Technical Commission on Aeronautics ("RTCA") Special Committee 155 (SC-155) is developing future user requirements, looking ahead for 25 years, and considering cost-beneficial new technologies to satisfy those requirements. The study is being carried out in support of the NAS modernization plan.

Mobile Satellite Corp.'s proposal to the FAA

On March 5, 1984, Mobile Satellite Corporation submitted a "Proposal for the Development of Aircraft Surveillance by Satellite" to the Federal Aviation Administration. The proposal describes a practical system for the United States, and a development plan that makes satellite capacity available to the FAA at virtually no cost during the system development phase. Full operational service would be available at about ten percent of the cost of a dedicated satellite system if the FAA chooses to use the commercial facilities of Mobile Satellite Corporation.

The proposed system will locate and identify 20,000 aircraft every four seconds with an accuracy of about 600 feet. Two-way data communications are included in the signaling, and voice communications are available, if desired. The system thus provides all elements needed for en route traffic control, independent position surveillance and instantaneous two-way communications. Its accuracy is sufficient for supplementary ATC over land areas and offers a much-improved basic ATC system for oceanic areas.

The surveillance system offered by Mobile Satellite Corporation has features that make it especially attractive because it is adaptable to even the highest level of traffic demand that may materialize and to a wide range of requirements for both communications and surveillance. It is extremely efficient in its use of radio spectrum because it uses many narrow-band channels instead of single wide-band channel. Its spectrum occupancy, and therefore the charges for its use, are proportional to need. Thus, if there is only a limited application, such as for rotor craft throughout CONUS and for all aircraft in the Caribbean, the satellite-based air traffic control system need only occupy about 100 KHz of bandwidth. If, however, it is necessary to track all the aircraft that are active in the United States during peak hours, the total spectrum occupied in the mobile band can be expanded, though it will still occupy less than 4 MHz.

The extremely high spectrum efficiency and adaptability is reflected in the low cost of the service. Even if the system were used to track all active aircraft, the cost of the service to the FAA would be about ten percent of the cost of a dedicated satellite. The cost savings result because spectrum is made available for other mobile

services that provide the bulk of the revenues that make the Mobile Satellite Corporation's system a viable commercial venture.

Mobile Satellite Corporation recognizes that as a matter of policy, the FAA may eventually wish to have its own operational satellite system despite the higher cost. In that case, we will vacate the necessary spectrum, up to 4 MHz, so that the FAA may implement its own operational system.

The Mobile Satellite Corporation surveillance system fully meets all prospective requirements for satellite-aided air traffic surveillance. Its accuracy is adequate for en route control and for collision avoidance. The system's high accuracy and its even higher precision are well within the maneuvering space of aircraft in flight and are a small fraction of the separation distances that currently must be maintained.

Mobile Satellite Corporation's surveillance system is based on tests and evaluation with NASA's Application Technology Satellites. The FAA was a major participant in the well-documented flight tests and demonstrations. (See References 3, 4 and 5.) Every factor affecting accuracy and performance has been identified, studied, and measured, and techniques for controlling the effects have been developed and tested. Millions of range measurements and position determinations have been made during the 17 years of experiments. All of the Application Technology Satellites of NASA were used, some at the VHF frequencies of present air-ground aircraft communications and others at the L band (1550-1650 MHz), which is assigned for aeronautical mobile satellites. (See References 3-10.)

In 1970, the FAA flew aircraft that were tracked simultaneously by precision radar and ranging from the ATS-3 and ATS-1 satellites. From these and other tests, the factors affecting accuracy and performance were measured. Even in those early tests, the performance of the narrow-band techniques was adequate for en route traffic control. Subsequent developments have improved the techniques to demonstrate accuracies as small as tens of meters.

Mobile Satellite Corporation's surveillance system uses a proven narrow-band ranging technique with an accuracy as high as the practical limits of wide-band techniques. The accuracy is achieved by measuring the internal time delay of the aircraft ranging transponder and sending the measurement in digital form along with the actual response to the ranging interrogation.

There are many advantages to the narrow-band technique. It is extremely efficient in its use of radio spectrum. The spectrum occupancy can be changed to match the number of aircraft that are served, and cost for the use of the satellite is proportional to the number of aircraft served. (Wide-band systems occupy a fixed spectrum regardless of the number of aircraft, and the full cost of the satellite system must be applied to the service.) The narrow-band system uses voice bandwidth radios so that the same aircraft equipment can be used for voice, data and surveillance. The narrow-band system has been exhaustively tested with geostationary satellites, aircraft, land, and marine vehicles over many years and under many conditions. Mobile equipments of conventional design have been used with the satellites and their performance is well documented. Wide-band ranging system have not been tested with geostationary satellites and suitable vehicle transponders have not been developed.

Mobile Satellite Corporation is technically and financially prepared to implement a commercial mobile satellite system. We will provide the full range of services identified for mobile satellites including mobile radio telephone, voice and digital dispatch, interactive data and position surveillance for the nonurban population of the nation and for transportation and other industries that operate in non-urban areas including the inland and coastal waterways. In accordance with our proposal to the FAA, we stand ready to provide satellite capacity and technical assistance in the development of a practical, economical aeronautical traffic surveillance system adapted in capacity, cost, and performance to any requirements that the FAA determines that it needs, and to do so either in the near future or in later years, as the agency may require.

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Senator KASSEBAUM. Mr. ROTHBLATT.

Mr. ROTHBLATT. Thank you, Madam Chairman.

My name is Martin Rothblatt with Geostar Corp. I am accompanied here today by Dr. Steven Cheston, Geostar's vice president for administration, and we apologize for Dr. O'Neill, our president's, absence. He is fulfilling a long-ago made promise to appear at the Royal Institute of Navigation Conference in London.

Madam Chairman, it is somewhat interesting that Senator Percy began by remarking that tragic events such as KAL 007 often trigger positive actions, such as the attention being paid now to satellite navigation systems. This was also the case in Geostar's genesis. It was the tragic 1978 collision between a PSA airliner over San Diego and a general aviation aircraft, which caused a great amount of turmoil in positively controlled airspace, and which got our president, Dr. O'Neill, thinking of a possible technical fix to this sort of problem.

In the testimony today, I would like to hit briefly on five points: What is Geostar? How does it work? What can the system do? What have we at Geostar been doing to implement the system? And, finally, in what areas can Congress be of assistance?

Geostar is a precision position determination system capable of serving up to millions of users with small inexpensive equipment. Geostar was privately conceived for public interest purposes, such as helping to prevent the types of disasters as occurred in San Diego—collisions.

Geostar is also privately financed, in proof of the policy which President Reagan spoke to earlier this year of encouraging free enterprise investment in space activities. Hence, Geostar is one of those few instances where private enterprise in pursuit of a profit motive can perform a useful public service function.

How does the Geostar system work? Essentially, Geostar is built of three components: the satellite system is one component, and we call that the space segment. Two satellites, at minimum, are necessary. There is a computer segment at a single Earth station location. And, finally, there is a user segment of small, inexpensive transceivers. A model of a miniaturized one is here.

In essence, this system works by having the computers determine the position of user equipment and then transfer this position location information back to the user equipment, using radiowaves.

Geostar's patented, random-access, TDMA type of methodology allows millions to be served at minimal expense.

What can the Geostar system do? In essence, Geostar simultaneously performs four functions: a navigation function; it helps users find out where they are; a radio location function; it helps other people find out where users are; digital messaging allows short messages to be exchanged among users; and fourth, computer-based value-added services such as terrain avoidance warnings.

In aviation, Geostar can provide an emergency locating transmitter or ELT function to assist search and rescue missions. Geostar can provide some en route navigational guidance and more precision service at the some 15,000 uncontrolled airfields in this country. These specific benefits to the aviation community have been supported in writing by organizations such as AOPA on behalf of its 250,000 members; AirInc., the communications operating company for the airline industry; major general aviation aircraft manufacturers, such as Piper and Beechcraft, and operators of large private airports, including the world's largest private airport near Los Angeles.

Geostar can also provide service and benefits in the land transportation and in the maritime areas. Here, Geostar provides emergency public services such as locations of accidents, hijackings of trucks, notifying public safety officials of the locations of such crimes. Geostar can provide a fleet dispatch service which allows industry, with many trucks and deliveries, to accomplish what is called just in time delivery or JIT, a major of manufacturing coordination technique that U.S. industry is trying to adopt. The Japanese have been doing it for a few years.

These specific public interest benefits through the land transportation sector have been supported by companies such as Emory, North American Van Lines, which have attended our tests, and in the maritime area similar services have been supported by the National Ocean Industry Association and large geophysical contractors.

What have we at Geostar been doing to implement these services? Our activities, Madam Chairman, fall into three categories: We have been pursuing vigorously technical verification of the system, market verification and regulatory verification. In the technical area, our system design has been reviewed, approved, and verified by major satellite manufacturers—RCA Astroelectronics, by Comsat General Corp., which is now under contract to us, providing a detailed RFP for the satellite system, and by other independent reviewers such as Systematics General Corp., a major DOD/NASA contractor in these types of matters.

Those are confirmations of our space segment, that the satellites will work. The computer segment has been verified. Our requirements there have been run through a Cray I computer under contract to the Cray Corp. We now have a memorandum of understanding with the National Oceanographic and Atmospheric Administration's National Ocean Service where we are working out the details for transferring their digital data base information through Geostar to end users in maritime, aeronautical, and terrestrial environments.

Finally, we have the user segment. We have worked with numerous manufacturers to define costs and prototype our user equipment. I am glad to report that the consensus of the latest five reviews demonstrates that this equipment can be built in large quantities at the \$450 range.

Finally, we at Geostar have synthesized all three elements—the space segment, computer, and user equipment—by building large-scale tests of the system. The first was done at Lake Tahoe, NV, where for satellites we put relays on mountain tops, demonstrated accuracies of 1 meter in aircraft landing, land mobile, and pedestrian circumstances. These tests were attended by numerous Government agencies, large corporations, all very supportive.

We are now implementing an airborne mobile test, where our satellites will be instead electromagnetic relays in aircraft on predefined flight paths, and this type of test we can bring to even the Washington environment and demonstrate the system's operational capability here.

Marketwise, we have had our markets confirmed by companies such as Booz-Allen and Touche Ross. We are receiving additional commitments of user interest from the aviation, land transportation, and maritime sectors.

Finally, on the regulatory front, over 95 percent of the comments on our application to the FCC for approval have been favorable, and we have been very fortunate to have received top-level support from the Commissioner level of the FCC.

Congress, fortunately, does not have to do anything specific for the final implementation of the Geostar system. At present, things are going on target for a 1987 implementation date. We are a supplemental service, and do not propose to perform air traffic control, and therefore no new legislation is needed for the authorization of Geostar.

We are, in essence, a manifestation of this country's open entry policy, an example that free enterprise can garner capital for investment in space.

One thing which Congress can do to both assist Geostar and, more importantly, to save lives over the next several years is to facilitate our ability to provide an emergency locating transmitter or ELT function. Presently, section 1491, title 49, mandates ELTs as a minimum performance requirement for general aviation. As this ELT requirement has been implemented in the FAR's and technical standard orders, they in essence precludes a system with Geostar's type of philosophy from providing an ELT service. We can locate aircraft accurately within 1 second. ELT's currently take about 5 hours. We can also provide two-way messaging to find out whether or not this is a real accident or a false alarm.

In essence, Geostar can save tens of millions—to hundreds of millions of dollars in U.S. search and rescue funds, can save lives, and can outperform current ELT's. We do not ask that Geostar transceivers be mandated in the absence of ELT's, only that it be made clear to the FAA through report language that the ELT requirement in section 1491 is not meant to preclude satellite radio determination systems such as Geostar from providing this function.

We naturally would expect that the FAA would eventually spec acceptable satellite radio determination systems within their tech-

nical standard orders before a Geostar transceiver would substitute for an ELT.

Currently, Geostar is moving quickly ahead because we have been able to rely on current policy favoring private initiatives in space communications. The Geostar initiative is one that will save many lives, that will save Federal search and rescue funds, and that will generally enhance U.S. economic development in numerous areas.

We appreciate the support of both the public and private sectors today, and appreciate this opportunity, Madam Chairman, to present our views on satellite navigation to the Aviation Subcommittee.

[The statement follows:]

STATEMENT OF MARTIN ROTHBLATT, VICE PRESIDENT, GEOSTAR CORP., UTILIZATION OF SATELLITE NAVIGATIONAL AIDS

This testimony describes the capabilities of GEOSTAR satellite navigation technology and explains the need to ensure that Section 1421(d) of U.S. Code Title 49 provides for GEOSTAR technology as a legal alternative to the use of existing emergency locator transmitters. The GEOSTAR Satellite System, approval of which is now pending before the Federal Communications Commission (FCC), offers near-continuous aeronautical navigational guidance and automatic identification—with meter-level precision—of the location of any GEOSTAR equipped aircraft within a second of a crash. Section 1421(d) mandates installation of an emergency locator transmitter (ELT) on most fixed-wing aircraft. GEOSTAR's superior method of position determination and reporting meets the objectives of mandatory installation of ELT's, but does not involve any use of a current-type ELT. By clarifying that the scope of Section 1421(d) includes GEOSTAR technology, Congress will ensure that American aviation is as safe as technology and economics allows.

GEOSTAR is a private company, established to provide accurate navigational and communications services commercially from special satellites. It has not requested any subsidy or development funding from the Federal Government. To date, GEOSTAR has raised several million dollars from private sales of stock. Some of those funds were spent on the construction of a full test system, the operation of which is captured in a short film that we would be glad to show to Subcommittee members. The Company plans to begin service to the entire continental United States in 1987.

All GEOSTAR services will be provided to simple, inexpensive "transceivers." The transceivers send and receive digital messages, relayed through GEOSTAR satellites to a computer at the GEOSTAR Central ground station. Transceivers can be designed for mounting in aircraft, boats, trucks or cars. There will also be transceivers powered by penlight batteries, small and light enough to be carried by hand.

The model GEOSTAR portable transceiver has a display and a keyboard like a pocket calculator, with numbers and the letters of the alphabet. Cost studies carried out by five manufacturers independently verify that with sufficient manufacturing volume this transceiver can be sold at retail for about \$450 in 1984 dollars.

The main markets and sources of revenue for GEOSTAR will be the land transportation industry, boating and emergency services. Therefore GEOSTAR can serve the aviation community at low cost because nearly all the revenue support for the system will come from much larger communities of users.

The capabilities of the GEOSTAR system which make it uniquely effective for aviation are:

(1) Low cost of equipment and low service charges, estimated at about \$20 per month. These low service charges are possible because the full system has a high capacity of about 55 million messages per hour.

(2) High precision in navigation, nominally 2 to 7 meters. In system tests, a precision of one meter has already been demonstrated. The GEOSTAR Central computer, which does all computations in the system, can provide that high accuracy to each transceiver in the form of navigational fixes or direction steers.

(3) Position information for an aircraft fleet dispatch headquarters, giving the position of all aircraft in the fleet both in the air and on the ground.

(4) Terrain avoidance information, warning an aircraft of obstructions ahead, including such mandate obstructions as TV towers.

(5) Collision avoidance information, providing the pilot in the cockpit with information on the location and course of every other GEOSTAR-equipped aircraft nearby.

(6) Two-way digital message service, between an aircraft and any GEOSTAR transceiver, for example at its home or destination airport.

(7) Emergency warning and rescue service. GEOSTAR can provide within one second the location of a crash, and its two-way message capability can be used to prevent false alarms.

In future years, if GEOSTAR is eventually approved by the FAA for precision approaches, it could provide instrument approach service to the more than 12,000 airports in the United States which do not have enough traffic to justify ground-based Federally supplied approach aids. This week the GEOSTAR Airborne Test System began operations over an area including Princeton, New Jersey, the Company's headquarters. That system is fully air mobile, and can later be set up for demonstrations covering the Washington, DC metro area if requested by the Committee.

GEOSTAR's applications to the Federal Communications Commission for radio frequencies are supported by many letters from airline and general aviation interests, as well as from companies in the land transportation and geophysical exploration industries. For example the Aircraft Owners and Pilots Association—on behalf of its more than 200,000 members—told the FCC that:

"The capacity of the GEOSTAR Satellite Service to report instantly the location of aircraft which are either downed or in other distress situations represents a potentially major breakthrough with substantial life-saving ramifications."

GEOSTAR has also been supported before the FCC by several agencies of the Federal Government, each of which plan to use GEOSTAR services.

GEOSTAR proposes to provide all of its services to aviation on a supplementary basis, paid for by those aircraft owners and pilots who make the free choice of buying the extra services. It does not propose to substitute for the existing services provided by the FAA and supported by taxes. The Company has only one substantive request to make of the Committee—to make clear through Congressional direction that the scope of the statutory ELT requirements includes the GEOSTAR transceiver.

After the effectiveness of the GEOSTAR system has been fully demonstrated by the Airborne Tests and by independent reviews, it may be advisable to slightly modify existing Federal law to expressly allow aircraft owners to substitute a GEOSTAR transceiver and GEOSTAR service for the current type of ELT. The ELT is not a part of the FAA's air traffic control system, and it has a history of approximately 98% false alarms, as well as relatively poor reliability and low precision in locating crashes. We believe that the substitution of GEOSTAR service for the ELT function will save resources now being wasted in pursuing ELT false alarms, and will save many lives by the speed and precision with which GEOSTAR can guide rescuers to crash survivors. A more detailed explanation of the need for Congressional assistance in allowing pilots to voluntarily substitute a GEOSTAR transceiver for the presently mandated ELT is set forth below.

BACKGROUND ON SECTION 1421 (d) AND CURRENT ELT REQUIREMENTS

Section 1421(d), enacted on December 29, 1970 as Section 31 of Public Law 91-596, mandates that "emergency locator transmitters shall be installed" on a broad range of fixed-wing, powered civil aircraft.¹ The Administrator of the FAA is empowered to prescribe specific minimum standards for the mandated ELT's. 49 U.S.C. Section 1421 (a). The Section was enacted in response to the growing number of deaths attributed to delay in locating survivors of downed aircraft, and to the emotional and legal-estate problems resulting from the inability of authorities to ever locate many downed aircraft at all. 1970 U.S. Cong. & Adm. News 5177. The emergence of inexpensive ELT technology in the 1960's provided Congress with a technological means to address these serious, nationwide problems.

The FAA subsequently amended its FAR's to add a new Section 91.52 ("Emergency Locator Transmitters") providing that "no person may operate a U.S. registered civil aircraft unless . . . attached to the airplane [there is] an automatic type emergency locator transmitter that is in operable condition and meets the applicable requirements of TSO-C91." 14 C.F.R. Section 91.52. Subsections to this basic regulation exempt certain classes of aircrafts and address battery replacement and ELT removal contingencies. TSO-C91, stated in Section 37.200 of the FAA's Technical Standard Order Authorizations, incorporates (with slight modification) the type

¹A 1974 amendment substituted the word "transmitters" for "beacons".

equipment standards set forth in Radio Technical Commission for Aeronautics (RTCA) Document No. DO-147 as "the minimum performance standards that airborne emergency locator transmitters must meet." A pending FAA Notice of Prepared Technical Standard Order, TSO-C91a, would substitute RTCA Document No. DO-183 for the older DO-147 as the new ELT performance standard.

The standards stated in RTCA Document Nos. DO-147 and DO-183 specify a wide range of equipment performance and design standards for ELT's. For example, (1) radio transmissions must occur simultaneously on 121.5 and 243.0 MHz, (2) the transmitter must be automatically activated when its crash force sensor is subjected to a specified force for a specified number of milliseconds, and (3) the transmitter must not be activated if conditions do not reach the automatic activation level. These standards are consistent with the ELT's Congress contemplated in enacting Public Law 91-596 and with the industry's consensus as to what constitutes an ELT. They do, however, completely preclude the possibility of GEOSTAR user equipment—which operates pursuant to a completely different concept of emergency rescue technology—from ever being considered as an "ELT" within the contemplation of 49 U.S.C. Section 1421(d).

THE INADEQUACIES OF ELT TECHNOLOGY

There is consensus throughout the aviation industry that ELT technology is not the best solution for aircraft search and rescue. The RTCA, in its report on ELT technical and operational problems, observed that:

"Controversy has surrounded the use of the emergency locator transmitter (ELT) since 1970 when Congress mandated its installation in most general aviation aircraft. Normally, ELTs are crash activated and intended to expedite the location of downed aircraft by searchers. However, the ELT has been plagued with many technical problems that severely limit the usefulness of these potentially life-saving devices. *A high rate of non-distress activations and failure to activate in crash situations are the two most blatant ELT malfunctions.*" RTCA Document No. DO-182 (November 1982) (emphasis supplied).

The same report noted the following additional evidence of systematic ELT problems:

The mean transmission duration for an ELT—the time it takes to precisely locate an ELT—is approximately 5½ hours. RTCA DO-182 at 3.2.5.

Over 95% of reported ELT activations are false alarms. Unreported false alarms, however, may be as high as five times the number reported. RTCA DO-182 at 3.1 and 3.2.5.

An estimated one in every ten ELT units triggers unnecessarily. RTCA DO-182 at 3.3.6.

Hence, Congress is faced with essentially the same problem it tackled in 1970—an important public need for adequate aircraft search and rescue technology is not being met. The GEOSTAR Satellite System can meet this need inexpensively, accurately and with no false alarm problem. Congressional clarification that the scope of Section 1421(d) includes GEOSTAR technology is needed to gradually implement this solution. The benefits to the American public for Congress taking the needed action are described below.

CAPABILITIES OF THE GEOSTAR SATELLITE SYSTEM

Automatic interactions among the three components of the GEOSTAR Satellite System permits near-instantaneous determination of the precise location of downed aircraft, helps to avoid air tragedies via en-route navigational advisories, and allows Search and Rescue (SAR) teams to ascertain the physical status of crash survivors. The GEOSTAR Satellite System performs these and many other functions without any systematic false alarm problems and for a cost, to users, of just a few dollars a month. Finally, by eliminating the need to send expensive SAR teams after false ELT alarms, the GEOSTAR Satellite System saves the government millions of dollars—and costs the government nothing.

The first component of the GEOSTAR System is a set of three satellites in geostationary orbit. These satellites operate at special frequency bands which render them immune to current problems of orbital congestion. The second component of the GEOSTAR System is a piece of user equipment called a "transceiver." It is very lightweight and durable and has been priced by several manufacturers in the \$450 range. The third component of the GEOSTAR System is a high-speed central computing facility located near GEOSTAR headquarters in Princeton, New Jersey.

One hundred times a second the satellites electronically interrogate all user transceivers—in essence asking each transceiver if it has any message to send. Each

transceiver automatically responds to these interrogations at user-defined time intervals with a unique digital identification code. The responses of the transceivers are relayed by the satellites to the central computing facility. A bank of triply-redundant computers is able to determine the precise location of each transceiver because up to three identical transceiver codes will arrive at the computers at three different times—the “via satellite” transmission distance from the transceiver to the computer will be different for each satellite.

The computers automatically and continuously monitor the position of each transceiver and compare these positions with those of digitally-stored navigational obstacles (e.g. mountains; towers) and aids (e.g. landing areas). The positions and automatic navigational advisories are sent back to the transceivers via satellite. When the computer detects that a transceiver is on a track that will intersect terrain (other than a landing path), it automatically transmits emergency “pull-up” advisories to that transceiver. If the transceiver's track does in fact intersect terrain, the computer knows that a crash may have occurred and the precise location of that possible crash. This crash information is immediately and automatically transmitted to the Air Force Rescue Coordination Center (AFRCC)—the designated Federal organization for coordinating SAR activities in the continental United States. At AFRCC, SAR officials will use GEOSTAR's two-way messaging capability to confirm whether a crash has occurred and to assess the status of any survivors. AFRCC can then use GEOSTAR's navigational capabilities to direct a SAR team to the precise location of the crash.

The foregoing description identifies many of the unique advantages the GEOSTAR system has over one based on ELT's. The GEOSTAR transceiver operates continuously; ELT's are *supposed* to work only after the aircraft has crashed. The GEOSTAR system helps to avoid crashes through computer-generated navigational advisories; ELT's are “dead weight” at all times except *after* a crash. The precise location of any GEOSTAR transceiver can be determined in under a second; on average it takes over five hours to locate an ELT. The GEOSTAR system includes a two-way messaging capability for confirmation of emergencies; ELT's have no emergency confirmation capability—the only way to determine whether or not a crash has occurred is to (at great expense) go out and find the transmitting ELT.

The only failure modes for the GEOSTAR system are (1) failure of a transceiver to operate, (2) loss of satellite power and/or control and (3) computer facility malfunction. However, the chances of any one of these components failing is miniscule compared to the failure rate of ELT's (up to 10%). Airborne GEOSTAR transceivers will be built to high mil-spec standards. They will begin transmitting as soon as the pilot turns on his or her ignition. Any failure to transmit will be detected on the ground or enroute—unlike an ELT, the GEOSTAR transceiver does *not* have to operate after a crash. All GEOSTAR satellites will be fully redundant, and a fourth spare satellite will be kept in orbit. Any two out of GEOSTAR's four satellites can perform all necessary radiodetermination functions. The computing facility will consist of three completely independent and redundant systems. Failure of even two out of three of these computers will not affect system operations.

While no SAR system is perfect, the GEOSTAR system is far superior to the present one based on ELT's. At minimum, Congress should provide the American public with the GEOSTAR system as a mandatory alternative to the problem-ridden ELT system. In so doing, Congress will greatly enhance air safety and SAR while saving the many millions of dollars that are now wasted on tracking down false ELT alarms. The legislative effort needed of Congress, described below, is minimal.

WHAT CAN CONGRESS DO

Congress mandated installation of ELT's in most fixed-wing aircraft because the devices were an inexpensive means for addressing a serious SAR problem. GEOSTAR transceivers will be equally inexpensive, and are a far more capable SAR aid. Hence GEOSTAR transceivers should be a legally acceptable alternative to current-type ELT's for the same reason Congress mandated ELT's—the public interest in a comprehensive technical fix for the many problems caused by lost aircraft. Furthermore, for manufacturers to bring GEOSTAR transceivers to the market as quickly as possible it is important for there to be Congressional recognition of the transceiver's ability to substitute for ELT's. Hence Congress is urged to provide clarification that the scope of Section 1421 (d) of Title 49 encompasses GEOSTAR technology.

Senator KASSEBAUM. Thank you very much. I might just start with you on a question which you raised at the end regarding

ELT's. I think you probably heard my question to the FAA regarding that. How do you respond to their belief that, as a matter of fact, the Geostar is not developed enough yet to do that, and that they say, as a matter of fact, that an emergency could be triggered off by Geostar if a helicopter would land off airfield?

This is something that has not been ironed out yet. Whether it could be or not, I suppose you would have to answer. How do you answer these concerns?

Mr. ROTHBLATT. First of all, the two primary concerns which the FAA spokesman raised, one relating to whether or not Geostar has sufficient capacity to handle the number of aircraft; and second, whether or not Geostar's technology is able to quickly sort out all the signals coming into our computer data base—these questions really relate more to an air traffic control type of function than to the ELT function which Geostar intends to provide.

ELT's are activated at relatively rare intervals compared to an air traffic control function and, beyond that, Geostar has adequate capacity to handle upwards of 180,000 aircraft, responding on the order of every second to interrogations. Geostar essentially makes the false alarm type of problem which you mentioned for a helicopter on an airfield impossible, because should such an emergency be triggered, the first thing which is done is the computer automatically generates a confirmation digital message to that point.

In this way, no search and rescue team has to go out in the blind, which is the case with current ELT's. So the big difference with Geostar is it is a two-way system. There is always an opportunity to confirm that an emergency is real. The current ELT's are simply a one-way system. There is no confirmation loop. In fact, everyone who has looked at Geostar's capabilities in emergency locating transmitters—AOPA, general aviation manufacturers—have said this is one piece of equipment we do not mind adding to our cockpit.

The FAA spokesman mentioned earlier that general aviation does not like to add a lot of equipment to their cockpit. Here is an example where they have come forward and said this is one thing we think is really valuable, we would be willing to add. It was mentioned earlier by Senator Percy that errors are inevitable and that a \$15,000 cost for a NAVSTAR receiver is trivial compared to the lives which could be saved.

We would certainly agree, and believe that the Geostar system operating in the supplemental mode makes it still less likely that errors will occur and that the \$450 to perhaps a few hundred dollars more for a transceiver is a still more insignificant price burden and, in any event, one which the aircraft industry themselves have expressed support for.

Senator KASSEBAUM. So it would be about, you say, \$450 above an ELT?

Mr. ROTHBLATT. No. The mass production price for a Geostar ELT would be \$450. Current ELT's are in the \$250 to \$500 range. The current ELT does—really, the main reason why we at Geostar have pushed this is it comes down to a couple of simple differences. The current ELT's are deadweight in the aircraft at all times. They are never supposed to operate until the aircraft has crashed into a hillside and is engulfed in flames. At that moment, they are sup-

posed to operate, and then search and rescue teams have to find where the device is.

Geostar provides useful service from the moment the aircraft is turned on until the aircraft is turned off: digital service, en route navigation. And finally, with Geostar, collision is recognized when the transceiver's track as monitored by our computers intersects terrain at a location other than an airport.

So, rather than having to work only after it crashes, Geostar needs only to work up to crash, which is philosophically a much more logical approach. Beyond that, Geostar can provide navigational advisories when the computers notice that the aircraft's track is intersecting a large mountain or large towers which are stored in the data base—pullup advisories can automatically be transmitted.

Senator KASSEBAUM. Now, you see Geostar as a supplemental; is that correct? Mr. Anderson, Mobile Satellite is regarded, if I'm correct, as a total substitute of private operation of air traffic control. Is that correct?

Mr. ANDERSON. No, that is not. Mobile Satellite Corp. will own and operate satellites in geostationary orbit for land and aeronautical purposes. We will make capacity available to the Federal Aviation Agency for operation of their system through our satellites.

Senator KASSEBAUM. Much as Geostar would wish to do as well.

Mr. ANDERSON. Yes. We are entirely a commercial enterprise, a commercial venture, and most of our revenues, of course, will be drawn from the land and other services that we provide. The total air traffic control surveillance requirement will take only a small part of our total capacity.

Senator KASSEBAUM. I am just curious. Everybody seems to have been in London one way or another at this meeting. What is being done abroad and how much coordination do we have, say, with the Japanese or the French, the British, whoever may be involved in similar development?

Can you answer that, Mr. Anderson, or anybody speak to that?

Mr. ROTHBLATT. Madam Chairman, it is really, I think, a matter of U.S. leadership. Several entities around the world are interested in developing the satellite navigation systems. The Japanese Government, together with Japan Air Lines, is in the development of concept design phase for a Pacific Ocean region satellite navigation system. The Europeans are in the development phase of a so-called NAVSAT system which would be somewhat similar to NAVSTAR GPS.

The Soviets, as you may be aware, have already, I believe, five satellites as part of their GLONASS system. The position of Geostar is sort of twofold. On the one hand, we are proposing simply a U.S. service, so that we do not feel that there is a connection, and there is not a connection between implementation of Geostar and, say, implementation of NAVSTAR, which serves totally different requirements, or further development of the NAS which is geared toward positive air traffic control.

On the other hand, we feel it is important for the United States to develop Geostar's radio determination technology to maintain leadership in satellite communications, to have perhaps a viable export product to allied nations which may wish to develop their

own domestic radio determination systems. So worldwide coordination on the single system has been the elusive goal for quite a long time. I think it is a worthwhile goal to keep striving for.

In the meantime, the United States cannot afford to fall behind Japan or Western Europe in the development of satellite navigation systems.

Senator KASSEBAUM. Mr. Degroot.

Mr. DEGROOT. Madam Chairman, you mentioned the conference in London that was sponsored by the Royal Institute of Navigation. There were approximately 300 people in attendance, and, I would guess from looking at the attendance list, that there were approximately 200 from European nations, about 50 from the United States, and about 50 from other nations.

The purpose of the conference was to determine what information may be available in the present and the future timeframe from navigation satellites. One of the things that was very effectively communicated at the conference was that the NAVSTAR system is the only system that is currently available in a near production configuration. There are other systems that are being discussed.

Representatives of the European Space Agency talked about the NAVSAT Program, which is an idea that is trying to get off the ground. It was indicated at the conference that to bring the system to the test configuration would require the expenditure of about \$2½ billion. A representative of the Soviet Union described their GLONASS system, indicating that it's primary application was for Soviet maritime applications.

He specifically invited other nations not to participate.

He indicated that it was desired that they develop the system first, and when it is ready, the Soviet Union may make it available to the rest of the world. In both instances, both the European NAVSAT and the Soviet GLONASS system, discussion on user charges was one of the topics. Both nations, both organizations stated that they would not have user charges. Questions of user charges on the NAVSTAR were subject to the results of this hearing and to the two related concurrent resolutions that are currently pending in both Houses of Congress.

I believe that when we look at the U.S. leadership position on navigation satellites, that it is correct to say that the NAVSTAR system is here now. As you are aware, the satellites have been procured for the production and operational deployment. They are ready, they are starting to be built now, and they will be available for full operational deployment in 1988. The other systems are in various stages of thought, paper design and some developmental and prototype equipment.

Senator KASSEBAUM. Mr. Degroot, I would like to ask you what real incentive would there be for a commercial user to equip a plane with a GPS until it is fully operational, and that would be—what—1988?

Mr. DEGROOT. Yes. I believe that there are several incentives. One of the things that we know without any question is that in aviation, because of the need for conservatism and the need for proving something before we become totally dependent on it, requires a period of getting acquainted.

It took several years, 5 or 8 years, before inertial navigation systems were finally accepted by the flight crews. So I believe that the first benefit of deploying NAVSTAR equipment onboard aircraft will be that elusive element of getting acquainted with the system. Getting enough confidence in the system that some day we may be able to utilize it as a sole means of navigation.

Perhaps, though, the greatest benefit that I see in the near term is that NAVSTAR can be used as an independent position monitor, independent of all other navigation systems, to autonomously determine the location of the vehicle.

If that is tied into reliable and long-range communications back to air traffic control, in areas where there is not radar coverage, in areas such as happened on KAL 007, the air traffic control centers would have a continuous plot in real time as to where the aircraft is. When the aircraft begins to deviate from its planned flight, there would be an instant alarm raised in the air traffic control center. That is one of the lifesaving benefits that I indicated earlier in my formal words.

I believe there is a third area as to why airlines would be interested in the NAVSTAR system, and that relates to the cost of the user equipment. Today, an aircraft that utilizes three inertial systems will spend approximately a half million dollars in the initial procurement of that equipment, and spend approximately \$50,000 a year maintaining that equipment.

A NAVSTAR receiver would cost about \$10,000 apiece, or \$30,000 per aircraft and no more than \$1,000 a year in maintenance costs.

So I believe there are three reasons why people would be interested in NAVSTAR: (1) to get acquainted with the system and to gain confidence in recognition of the time that it would be fully deployed; (2) the immediate lifesaving benefits provided by surveillance; and (3) the economics of the equipment.

Senator KASSEBAUM. I thank all three of you very much for your interesting testimony and appreciate the ability to have the opportunity to pull all this together. As I say, I think it is absolutely crucial that we do focus on how this is all going to fit together.

Thank you very much.

The last panel, composed of Mr. Fleming, Mr. Warner, and Mr. Winant.

Mr. John Winant.

Mr. WINANT. Would you like me to be the leadoff?

Senator KASSEBAUM. Well, let me go down and introduce everybody, and then I will let you be the leadoff.

STATEMENTS OF JOHN H. WINANT, PRESIDENT, NATIONAL BUSINESS AIRCRAFT ASSOCIATION; ROBERT P. WARNER, AIRCRAFT OWNERS AND PILOTS ASSOCIATION; AND ROGER FLEMING, VICE PRESIDENT OF OPERATIONS, AIR TRANSPORT ASSOCIATION

Mr. WINANT. I am John Winant, president of National Business Aircraft Association. I am delighted to be here this morning. Would you like us to go in the order listed, Madam Chair?

Senator KASSEBAUM. No. Why don't you just go ahead? You can start off, and we will go down the table.

Mr. WINANT. All right. I will be pleased to do so.

I come here not as a technician, and I want to make that point clear. I am not involved either in the development or manufacture of any system, and I come therefore to speak strictly from a user's perspective, and I think rather from a policy kind of standpoint, rather than that of a technical viewpoint. And I guess I ought to make it clear also that I was not invited to appear at the ION meeting in London.

Our purpose today is to caution the panel, if we may, and the Congress as a whole that to move too precipitately on this issue may be contrary to the best interests of civil aviation. The entire question of user requirements for satellite-directed navigation systems, as well as for communications and surveillance systems, is a principal subject of an in-depth study being conducted right now by the Radio Technical Commission for Aeronautics, or RTCA.

The RTCA effort is a vital element in an ongoing attempt by the Federal Government to delineate a comprehensive U.S. policy in this matter, and I would like to emphasize that the RTCA activity is an effort in which the requirements of the civil aviation users are predominant to the interests of the manufacturers of systems.

It is my own personal honor to have been chosen to chair the steering committee for this ongoing RTCA effort. It is charged with developing a statement of operational and technical requirements of users of the civil aviation system for communications, navigation, and surveillance for at least the next quarter century.

The study will include examination of existing and proposed technologies, system architecture, institutional and management issues pertaining to the eventual system, and the cost effectiveness of proposed technology.

The committee's emphasis will be on requirements to satisfy future needs of all users, as well as to examine the international aspects and ramifications of such systems implementation.

Also barely underway is a similar effort of the International Civil Aviation Organization, or ICAO, which is aimed at exactly the same goals as that of our RTCA. The ICAO's council, its governing body, agreed last fall to the establishment of a special committee on future air navigation systems. It is known by the acronym FANS, and it will hold its first meeting in July.

It should be noted that these two efforts, that of RTCA and that of ICAO, are not redundant, but instead complement each other. Further, it should be noted that the ICAO effort, like that of RTCA, deals not only with navigation but will encompass communications and surveillance as well.

I personally seriously doubt that there will be any international agreement which governs oceanic navigation, communication, or surveillance systems until FANS so agrees.

The RTCA effort is important because its membership represents all aspects of U.S. aviation—domestic and international, civil, and military. What comes out of this study, I believe, can be relied upon as the definitive statement of the users' requirements for the next generation navigation, communication, and surveillance system.

I must add, however, that it may well be into 1985 or even later before SC 155 completes its work and presents its findings. Conse-

quently, we would like to urge that the Congress not endorse in any kind of binding fashion the use of any system until the users decide what capabilities the system should have. All in all, much more needs to be learned about GPS and decided upon by the users before any satellite-based navigation system can expect to see widespread use for a significant period of time.

The wisest course available to the Congress in our view would be to defer any binding kind of judgment in this matter until at least such time as RTCA's special committee 155 has presented its final report.

In short, we do not feel that technology should be permitted to dictate the answers to questions which have not yet been formulated.

Thank you very, very much, Madam Chairman.

Senator KASSEBAUM. Thank you very much.

Mr. Warner, AOPA, Aircraft Owners and Pilots Association.

Mr. WARNER. Good morning, Madam Chairman.

My name is Robert Warner. I am senior vice president for Government and public affairs at AOPA. Our statement being a matter of record, I would just like to take a few minutes this morning to touch on three basic points. First, though I would commend Senator Percy for his leadership and you for your vision in looking forward into the needs of aviation perhaps even beyond the Brown Book and beyond what the FAA is currently looking at.

The three points I would like to discuss are; first, that satellite navigation indeed has much to offer general aviation; second, a little bit about FAA's reaction, action, or lack of action in this area; and finally, address the fact that this is not only an aviation matter, but an international aviation matter.

AOPA probably is most concerned about this and any future planning in aviation by virtue of the fact that there are 202,000 civil aircraft in the United States and our members own 170,000 of those 202,000 aircraft. Therefore, we have great interest in future equipment, including navigation, communication, and all other systems.

First, satellite technology does have a lot to offer to general aviation. There has already been considerable discussion this morning on the subject of search and rescue; the question of whether satellite technology can replace or at least supplement ELT's. We feel that is very much a possibility and indeed superior service can be provided.

I would take exception with earlier statements by the FAA that the current ELT system is adequate, and would go into more detail on that if you like.

Navigation, of course, is the primary subject of this discussion, but it is only one of the services that could be provided by satellite technology. As mentioned earlier, communication, surveillance—the entire air traffic control system surveillance of the position of aircraft—can be done by satellite and perhaps should be. As Mr. Winant said, these are questions that are still being asked, and being answered very quickly by the private sector.

Also, collision avoidance between aircraft and between aircraft and terrain, tall towers, and the like is also made possible by a quickly advancing computer technology.

AOPA believes all the services that can be provided by any future, complete system should be available. AOPA is very much involved in the RTCA and ICAO efforts. Further, the International Council of AOPA's of which AOPA-U.S. is a member, is also involved in the ICAO effort.

We believe that need should dictate what the aviation system is and what it will be, not tradition. General aviation needs low altitude navigation coverage. We need coverage of signal in remote areas, over the ocean, and we need approach guidance to many, many more airports—not more precise approach aids than we have today with ILS, but at more locations, to more airports, to serve more communities. We do not feel burdened by accepting ground-based systems. As I said, needs, not tradition, should dictate. One of our concerns of the FAA's Brown Book—the FAA national airspace plan—is that indeed it builds on tradition, rather than needs. It is a collection of systems. We said it when the book was first published; we said it last year, and this year, and you can expect us to say it again next year. There are some excellent programs within the Brown Book, and we have endorsed those all along the way. There are also some that we feel do not meet the needs of the users.

Our concern over the plan, as it relates to today's discussion is that the plan may be overcome by events. The first issue of the Brown Book did not even mention satellite navigation as a possibility. We expect the revised issue we will see in a few weeks will mention satellites. This is by direction from higher levels of government, not by initiative of the FAA.

Loran C, which is a maritime navigation system, is a perfect example of the private sector overcoming Federal Government's ability to have an aviation navigation system in place. There are people that are buying that equipment, installing it in aircraft, going through very bureaucratic processes to have it approved for aviation navigation, since its origin is for maritime.

As I said, aviation has been built on tradition. As you know, we started off with bonfires for en route navigation; eventually we had lights along the route; then we went to low frequency ranges; and eventually to VOR's. FAA's vision, if you will, is to say let's provide solid state VOR's, and indeed that is a good idea as a stopgap. And now by initiative of someone else, not themselves, they have said let's look at GPS. That is about the only discussion we hear from the FAA, that they have been directed to investigate GPS. That is not looking forward, in our opinion, as we see this committee doing—searching for facts and information.

I would suggest that we will have satellites in place and being used for aircraft navigation before we have microwave landing systems in widespread use by general aviation aircraft in the United States.

My final brief point: This is an international matter. Until the most recent witnesses, I do not think we had much discussion of the ramifications from an international standpoint. The coverage can be global. It need not be, but it can be. And, in fact, the accuracy that can be provided by satellite navigation would be the same whether it was offshore of the Gulf of Mexico for use by helicopters

for oil exploration, or whether it is in downtown New York, or whether it is the middle of the Amazon.

I need not tell you, Madam Chairman—there are considerable questions of international politics which must be answered to determine if that is the appropriate way to go. I, too, as was mentioned earlier, would like to see the United States be the leader and the United States have satellite systems in place. If it is not done by the United States as a Federal Government responsibility, it will be done by the private sector and/or it will be done by other countries in the world and offered to us, possibly with various stipulations on its use.

Thank you for the opportunity to be here this morning. We appreciate the opportunity to testify and also to submit our comments.

[The statement follows:]

STATEMENT OF ROBERT P. WARNER, SENIOR VICE PRESIDENT, GOVERNMENT AND PUBLIC AFFAIRS AIRCRAFT OWNERS AND PILOTS ASSOCIATION

I am Robert Warner, Senior Vice President, Government and Public Affairs for the Aircraft Owners and Pilots Association (AOPA). I appreciate the opportunity to appear before the subcommittee on Aviation to express AOPA's views on the subject of Satellite Navigation Systems.

AOPA represents the aviation interests of more than 265,000 individuals who own and fly general aviation aircraft for business and personal transportation. As a true cross section of the aviation community, they utilize the full range of communication and navigation services currently available to civil aviation.

GENERAL AVIATION TODAY

FAA statistics show that more than 80 percent of the general aviation fleet of 261,591 aircraft depend upon VHF omnidirectional radio range navaid (VOR) for short range navigation. Of this total population, 30 percent have distance measuring equipment (DME) and more than 50 percent are equipped with automatic direction finder (ADF). Even though this large percentage of the fleet is instrument flight rules (IFR) capable, only 2 percent have long range area navigation (RNAV) capability and more than 50,000 aircraft have no avionic navigation equipment.

To a large extent, use and geographic area of operation ascribe varied levels of desirability to available navigation systems for general aviation aircraft. For this reason there are examples of specialized avionics meeting deficiencies in the current airspace system. For example, Loran-C provides navigation and flight following for helicopters operating outside VOR and radar service coverage in the Gulf of Mexico; very low frequency-omega (VLF-Omega) now is commonly used for guidance over ocean and ADF still backs up VOR at locations below line-of-sight or where VOR does not exist. But, cost is of greater significance to general aviation in dictating selection and use of such systems than for other segments of the aviation community. However, proliferation of such noncompatible navigation systems does impose an expense to all users in dollars and/or operational limitations.

NATIONAL AIRSPACE SYSTEM PLAN

The VOR system projected by the FAA in the National Airspace System (NAS) Plan will continue to satisfy a large portion of the everyday needs of general aviation for the next 15-20 years, planned improvement is signal coverage and the increased availability of low cost VOR/DME area navigation equipment will sustain the current dependency on VOR as the primary navigation aid beyond the year 2000. There is no urgent need for a change in the navigation system mix, provided that the FAA does not decommission VOR and ILS facilities currently available and in fact implements planned improvements in VOR coverage.

Continued improvement in navigational service coverage for airspace not proposed by the NAS Plan—below 2,000 feet, line-of-sight, over water and in remote areas—would be welcome, particularly for helicopters, but we would not expect this coverage from short-range VOR systems. The capital expenditures and maintenance

costs are unacceptable for the limited use accruing to a majority of general aviation. Service in these situations might be best served by satellite systems.

AOPA does not support the concept that area navigation capability should be a minimum requirement for access to the national airspace system. Nor are we convinced that clear benefit exists in a transition to satellites as the sole basis for navigation. Additionally, we do not agree with the highly-touted combination of Global Positioning System (GPS) and microwave landing system (MLS) as "the" future air navigation system. GPS, in its present postulation, contains far too many disadvantages for civil acceptance (AOPA's reservations regarding MLS have been presented previously to the FAA and other congressional subcommittees). The FAA apparently has recognized this in part, since GPS is not highly visible in the NAS Plan. AOPA believes that satellites can and will play an important role in the future of aviation and we recommend that the FAA pursue satellite technology suitable for general use. Our commitment to that goal is demonstrated by active involvement in such efforts as the Radio technical Commission for Aeronautics (RTCA) Special Committee 155 and domestic contributions to the International Civil Aviation Organization (ICAO) Committee on Future Air Navigation Systems (FANS). Each of these assemblies of experts have been recently chartered to describe future user requirements for communications, navigation and surveillance service through the year 2010. FANS, in addition, will attempt to cope with the wide range of complex international implications inherent in adoption of future technologies in global application. The FAA must consider the product of these efforts before committing to any satellite system. They must objectively evaluate each available technology.

SATELLITE NAVIGATION

Since the Department of Defense (DoD) has decided that GPS is an absolute necessity, GPS may be a fact of life. However, a system that can provide multifunctions including navigation, communication and surveillance would be more attractive to general aviation. Other desirable functions such as search and rescue information and collision avoidance are required. Currently each of these are being considered as separate systems. Any proposition which fails to provide additional services including communication and surveillance, clearly does not represent a significant improvement over VOR/DME. The undesirable alternative in the case of satellites is a continued proliferation of separate systems and airborne equipment. Such implementation places an unacceptable burden on the provider of the system and on aircraft operators who must purchase and maintain avionics for access to certain airspace or to receive certain ATC services. General aviation will be best served by a single source concept, reducing airborne avionics by consolidation into a reasonably priced piece of equipment with expandable capabilities. Today few operators would pay a great deal for access to GPS primarily because the present system mix meets their needs.

General aviation represents a very large segment of the users of the NAS. Cost is a key consideration for them. The FAA should ensure that other available technologies do not offer better utility for less money before committing to a particular system.

CONCLUSION

AOPA heartily supports FAA's quest for future satellite navigation systems but is less enthusiastic about apparent dogmatic support for GPS. General aviation requires continuance of existing or improved VOR/DME and ILS capability, with MLS and Loran-C to meet some specialized needs. AOPA believes that multipurpose satellite systems providing navigation, communications, surveillance, search and rescue information, and collision avoidance should be identified and advanced for global application.

1. AOPA will continue to pursue a multipurpose satellite system which will provide navigation, communication, surveillance, search and rescue information, and collision avoidance.

2. AOPA wants FAA continuance of existing or improved VOR/DME and ILS capability, with MLS to meet specialized requirements that cannot be met by ILS.

3. AOPA believes that minimum performance specifications are a better approach than an attempt to standardize equipment.

4. AOPA will support the FAA and private sector development of satellite navigation systems.

5. General aviation will be best served by a single source concept which can reduce airborne avionics by consolidation into a reasonably priced piece of equipment with expandable capability.

6. AOPA desires to be involved in future proceedings in the satellite navigation selection process.

Senator KASSEBAUM. Thank you, Mr. Warner.

Mr. Fleming, vice president of operations, Air Transport Association.

Mr. FLEMING. Good morning, Madam Chairman. I, too, will summarize in the interest of saving your time and request that the full statement be included in the record.

Senator KASSEBAUM. Thank you.

Mr. FLEMING. We appreciate the opportunity to testify on Senate Concurrent Resolution 69 and on future enhancements to communications, navigation, and surveillance systems.

The resolution directs that the Secretary of Transportation make available to airlines the civilian version of the global positioning system satellite navigation system, and that the Secretary speed up the timetable for civilian use of GPS in international airspace. The principal objective of the resolution, as we understand it, is to preclude the possibility of gross navigation errors that could result in airline aircraft straying into airspace where there is the chance of hostile action. But we must ask whether the action contemplated in the resolution would achieve the desired objective. Unfortunately, we are not convinced that such is the case.

The GPS, like other modern navigation systems, is automated. A computer is used to perform navigation calculations, and a human being, a flight crew member, programs the computer. If the human being inadvertently programs the navigation system to direct the airplane to the wrong position, the GPS would only navigate the airplane more accurately to the wrong place.

According to the report published as a result of the ICAO investigation following the Korean Air Lines accident, it is unlikely that the extraordinary position deviation of flight 007 was due to lack of accuracy of the navigation systems installed in their B747 aircraft. To the contrary, inertial navigation systems have displayed remarkable accuracy in airline operation and are in general use by both U.S. and foreign air carriers.

Not all modern long-range airline aircraft use inertial navigation systems alone. Some employ hybrid systems with combinations of INS, augmented by Omega or very low frequency navigation systems. Such hybrid systems typically display even better accuracy than unaugmented inertial navigation systems. But all of these systems must be properly utilized by the flight crew and appropriate operational cross-checks must be employed to ensure that human data insertion errors or equipment malfunctions are not allowed to result in a serious navigation error. And I have included in the statement several examples of those operational cross-checks.

None of the navigation systems I have mentioned is foolproof, nor would a civil version of the GPS likely be foolproof. The potential accuracy of the GPS as a civil navigation aid is not an issue in this context. Although the civil version would not be as accurate as the military version, there is little doubt that the GPS technology provides highly accurate long-range navigation. But the GPS is likely to be subject to many of the same kinds of potential human errors that occur with the other currently used automated navigation systems.

Thus, it is not likely that availability of GPS would have prevented the Korean Air Lines tragedy. However, this does not mean that GPS has no civil role, but rather, that such a potential role must result from a systematic review of user needs and the technological options available to meet those needs.

Because of their functional interrelationship, communications, navigation and surveillance capabilities are frequently considered together and referred to as CNS functions. Services satisfying the operational requirements for these three functions may be provided by satellites or by other means.

The RTCA has recently established a special committee to look into these matters, and Mr. Winant has described that activity to you. The RTCA special committee was established at the request of the FAA, and FAA is the sponsoring Federal agency for this effort. Numerous other Government agencies will participate in the work of the committee, including DOD. Views of interested representatives of the international aviation community will be sought.

In addition, you have already heard that ICAO has formed a group—FANS is the acronym—to consider the operational requirements, institutional aspects, and practical economics of future international civil aviation systems. The United States, of course, is participating in that activity.

Approval at this time of a concurrent resolution directing that the Secretary of Transportation act to speed up the timetable for civilian use of GPS would prejudice the outcome of the RTCA and ICAO efforts. This could prove counterproductive if agreement is ultimately reached that GPS does not have an important civil role in the provision of CNS services.

For these reasons, we believe it is unwise at this time for the Senate to adopt Senate Concurrent Resolution 69. Instead, we recommend that further consideration of this matter be deferred, pending completion of the RTCA SC 155 effort.

Now, I might add a few words to what has been already said by Mr. Warner and Mr. Winant about the international implications, particularly with respect to surveillance of over-ocean traffic. Air traffic services are provided over the high seas in accordance with the ICAO rules of the air. These are as provided for in the Chicago convention.

The United States does not operate all the oceanic control centers. For example, between Anchorage and Tokyo, there is the Anchorage Center and Tokyo Center. On the North Atlantic, the principal centers are New York; Gander, provided by the Canadians; Shanwick, a joint facility which includes participation by Ireland with another part of the facility in Scotland; Reykjavik in Iceland; Santa Maria in the Azores Islands.

Thus, it is obvious that before there is to be surveillance service over the high seas, there must be agreement within ICAO as to who is going to provide that service, and how that service is to be provided. Airlines operating over the ocean—and I am sure this is true for other operators over the ocean as well—are not going to implement any new service unless there is ICAO agreement on what it is that has to be provided.

In this sense, then, the surveillance function needs to be considered separately from the navigation function. I would agree that

GPS most certainly will be investigated by the civil community in both its potential roles; that is, as a navigation aid and as a surveillance possibility. But again, to suggest that there will be ICAO agreement on the provision of surveillance capability within the immediate future is, I think, unrealistic. Very clearly, the ICAO Future Air Navigation Systems Committee work will have to run its course, and then there will have to be a regional air navigation agreement reached on the nature of those services.

Thank you.

[The statement follows:]

STATEMENT OF J. ROGER FLEMING, VICE PRESIDENT-OPERATIONS, AIR TRANSPORT ASSOCIATION OF AMERICA

My name is J. Roger Fleming. I am Vice President-Operations of the Air Transport Association of America. The ATA is a trade organization representing U.S. scheduled airlines, providing both domestic and international passenger, freight and mail services. We appreciate the opportunity to testify on S. Con. Res. 69 and future enhancements to communications, navigation and surveillance systems.

S. Con. Res. 69 directs that the Secretary of Transportation make available to airlines the civilian version of the Global Positioning System (GPS) satellite navigation system and that the Secretary speed up the timetable for civilian use of GPS in international airspace. The principal objective of the Resolution, as we understand it, is to preclude the possibility of gross navigation errors that could result in airline aircraft straying into airspace where there is the chance of hostile action. Major studies in the related fields of communications, navigation and surveillance capabilities are now underway by the Radio Technical Commission for Aeronautics at the request of the Federal Aviation Administration and by the International Civil Aviation Organization. Passage of S. Con. Res. 69 at this time, before these important studies are completed, may be premature.

But we must ask whether the action contemplated in the Resolution would achieve the desired objective. Unfortunately, we are not convinced that such is the case.

If the human being inadvertently programs the navigation system to direct the airplane to the wrong position, the GPS would only navigate the airplane more accurately to the wrong place. We will, however, offer a recommendation designed to reduce the probability of a tragedy similar to the one experienced by Korean Airlines while flying over the North Pacific on a route known as Red 20, linking Alaska and Japan.

According to the report published as a result of the International Civil Aviation Organization (ICAO) investigation following the Korean Airlines accident, it is unlikely that the extraordinary position deviation of Flight 007 was due to lack of accuracy of the navigation systems installed in their B-747 aircraft. To the contrary, inertial navigation systems have displayed remarkable accuracy in airline operation, and are in general use by both U.S. and foreign air carriers.

Not all modern long-range airline aircraft use inertial navigation systems alone; some employ hybrid systems with combinations of inertial navigation systems augmented by OMEGA or very low frequency (VLF) navigation systems. Such hybrid systems typically display even better accuracy than unaugmented inertial navigation systems. But all of these systems must be properly utilized by the flight crew, and appropriate operational crosschecks must be employed to insure that human data insertion errors, or equipment malfunctions, are not allowed to result in a serious navigation error. Such operational crosschecks include:

Prior to departure, independent verification by another crewmember of the accuracy of data entered into navigation computers.

Before entering oceanic airspace, verification of the accuracy of the inertial navigation systems position by comparing it with other aids.

As the oceanic portion of the flight progresses, periodic plotting and comparing inertial navigation systems position display with the planned track.

Finally, using the aircraft radar in terrain mapping mode to verify proper position with respect to prominent islands and peninsulas.

In short, none of the navigation systems I have mentioned is foolproof. Nor would a civil version of the Global Positioning System likely be foolproof. The potential accuracy of the GPS as a civil navigation aid is not an issue in this context. Although the civil version of the system would not be as accurate as the military ver-

sion, there is little doubt that the GPS technology provides highly accurate long-range navigation. But the GPS is likely to be subject to many of the same kinds of potential human errors that occur with the other currently used automated navigation systems.

Thus, it is not likely that availability of GPS would have prevented the KAL 007 tragedy. However, this does not mean GPS has no civil role, but rather that such a potential role must result from a systematic review of user needs and the technological options available to meet those needs. I will describe the processes that have been initiated to provide this review. But, first, let me say a few words regarding steps which we believe would more directly serve to avert another tragedy similar to the destruction of KAL 007 from occurring in the future.

In our view, the world aviation community should strongly urge that the U.S.S.R. establish communications between the agencies providing air traffic control services over Soviet airspace abutting the North Pacific routes and the United States and Japanese facilities providing ATC services in the Anchorage and Tokyo Oceanic Control Areas. With such point-to-point communications, routine transfer of flight plans of civil aircraft would serve to identify commercial air traffic to the Soviets.

The Soviets should also establish ground to air communications capability so that they can contact aircraft that they believe have strayed into their airspace.

In addition, provision of surveillance capability analogous to that provided by the domestic ground-based radar system may ultimately prove more important to avoidance of gross navigation errors in oceanic airspace than the provision of more precise navigation systems. Surveillance, combined with adequate communications, would provide an effective solution to the problem of human error in use of navigation systems. Such surveillance can be accomplished by several means, including use of satellite-based systems.

Because of their functional interrelationship, communications, navigation and surveillance capabilities are frequently considered together and referred to as CNS functions. Services satisfying the operational requirements for these three functions may be provided by satellites or by other means. The Radio Technical Commission for Aeronautics (RTCA) has recently established a Special Committee (SC-155) to:

1. Develop a statement of operational and technical requirements of users of the civil aviation system for Communications, Navigation and Surveillance (CNS) for at least the next quarter century.

2. Assess the operational and technical value of existing and proposed technologies including satellite technology, to meet requirements for CNS.

3. Identify system architecture to satisfy the operational and technical requirements.

4. Assess the institutional and management issues pertaining to implementation, operation and maintenance of CNS systems, including transition aspects.

5. Consider issues of cost effectiveness of proposed technologies as well as alternative cost recovery and financing mechanisms.

This RTCA Special Committee was established at the request of the FAA. FAA is the sponsoring federal agency for this effort. Numerous other government agencies will participate in the work of the Committee, including the military services. Views of interested representatives of the international aviation community will be sought. In addition, ICAO has formed a group, the Committee on Future Air Navigation Systems (FANS), to consider the operational requirements, institutional aspects, and practical economics of future international civil aviation systems. The United States has a member on this Committee and expects to base a large portion of input on the work of RTCA SC-155. In light of the efforts underway within RTCA and ICAO, we believe it would be unwise to take any action which could interfere with these deliberative processes.

Approval at this time of a Concurrent Resolution directing that the Secretary of Transportation act to speed up the timetable for civilian use of GPS would prejudice the outcome of the RTCA and ICAO efforts. This could prove counterproductive if agreement is ultimately reached that GPS does not have an important civil role in the provision of CNS services. For these reasons, we believe it unwise at this time for the Senate to adopt S. Con. Res. 69. Instead, we recommend that further consideration of this matter be deferred, pending completion of the RTCA SC-155 effort. We recommend that Congress obtain from FAA periodic progress reports on the RTCA and ICAO efforts to reach agreement on future requirements for CNS systems and to obtain reports on ICAO efforts to provide communications between USSR air traffic services units and those operated by the United States and Japan.

Thank you. I am now prepared to answer any questions you may have.

Senator KASSEBAUM. Thank you very much.

I would guess all three of you are in general agreement on the issue regarding the resolution; that there needs to be more time and the completion of this study to evaluate the various aspects of user fees, how this would be implemented. Is this study just dealing with GPS in a navigational role?

Mr. WINANT. I will attempt to answer that, Madam Chair. The RTCA study is dealing with all existing systems such as inertial navigation and Omega and the Loran type systems. It is looking into all kinds of candidate future systems. GPS certainly is among them, and is one of the leading systems which is under investigation. But there are others as well, including some which have been commented on by prior witnesses.

So the RTCA effort, I think, can be described very accurately as an extremely comprehensive look at all systems and variations thereon which might be useful in meeting the requirements of the civil users roughly from now until the early part of the 21st century.

One of the three subgroups of the RTCA Special Committee 155 is called the technical group. It is chaired by Dr. James Kramer, who was formerly Associate Administrator of NASA for Aeronautics and Space Technology, eminently qualified to lead an impartial investigation in which every possible candidate system is being examined on a totally open basis. Any potential manufacturer or manufacturer of existing systems has carte blanche opportunity to come before that group and to give an extensive briefing.

I would assume that the ICAO/FANS effort which will begin in early July with an organizational meeting in Montreal, will probably take a similar approach and will want to look at GPS, and it will probably want to look at the variant offered by the European Space Agency, ESA, the NAVSAT/PROSAT system. There are all kinds of acronyms out there—INTELSAT, INMARSAT, Sky Link, on and on and on.

So I would hope and would feel confident that all systems that have any credentials of quality will be given a very extensive examination.

Senator KASSEBAUM. And I would certainly concur with the comments that I think all three of you assumed, that Mr. Warner and Mr. Fleming highlighted, the international aspects of this. It does seem to me this is an enormously important effort that must not be overlooked.

Mr. WINANT. It cannot. I think all three of us agree on the overriding importance of that, and the creation of the FANS activity by ICAO, which is a very recent action by ICAO, underlines the feeling which we all seem to share.

Mr. WARNER. If I might, Madam Chairman, I would also like to add a comment on the international considerations. Just so there is no misunderstanding, I was not suggesting that ICAO efforts would be completed within the next couple of years; before any MLS is implemented in the United States.

Perhaps a moment of explanation. AOPA has worked in ICAO circles for many, many years and we know the progress of molasses uphill in January is sometimes a lot quicker than international cooperation on aviation matters. I was not suggesting that.

My point that satellites will be in orbit and be used onboard aircraft in this country within the next few years, is entirely within the realm of possibility. The latest estimate from Geostar of their launch dates is early 1987. This is only months past the current FAA MLS implementation date. Government contracts, procurement, and implementation history being what they are, indicates we should expect some slippage in the MLS dates.

However, we'll soon see private sector satellites going into orbit, probably for nonaviation purposes. Immediately, this equipment will be used in aircraft. If someone builds a better mousetrap that can be used in a general aviation airplane, I can assure you there will be general aviation aircraft owners that will be buying it. They will then be knocking on FAA's door for approval to use it within the system regardless of how it has evolved.

Senator KASSEBAUM. Thank you very much. I appreciate your thoughtful testimony today.

[Whereupon, at 11:55 a.m., the hearing was adjourned.]

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